SUPPORTING TEACHER COGNITION TOWARD TECHNOLOGY-ENHANCED LEARNING

By

Robert Walker

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Abstract

Despite near universal access to computers and the internet in schools, teachers often continue to use such technology as a substitute for traditional practices (i.e., using a computer rather than paper and pencil to write an essay or conduct research online instead of in the library) rather than to drive student-centered practices that support deeper learning. Such technology-enhanced instruction not only supports a richer understanding of curriculum but is seen as central to promoting the skills that students need to be successful in college and in their future careers. This mixed-methods study examined the impact that a multimedia-based teacher professional development program had on teachers' knowledge and beliefs about technology-enhanced learning as well as their ability to integrate such practices into their instructional environment. Ten teachers from an alternative high school participated in five face-to-face multimedia-driven lessons and three project development sessions in which they developed their own multimedia presentation. Quantitative data were collected through the Teaching Teachers for the Future-Technological Pedagogical and Content Knowledge (TPACK) survey and a TPACK survey constructed for this study. Qualitative data were drawn from the TPACK survey as well as focus-group interviews and classroom observations conducted in four cases study participants classes. Findings from both quantitative and qualitative data suggest that most participants developed new knowledge and beliefs about technology-enhanced practices but did not implement such practices within their classes.

Keywords: technology-enhanced learning, teacher cognition, TPACK, teacher self-efficacy

Dissertation Advisor: Dr. Stephen Pape

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Student's Name: Robert Walker

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The student has made all necessary revisions, and we have read, and approve this dissertation for submission to the Johns Hopkins Sheridan Libraries as partial fulfillment of the requirements for the Doctor of Education degree.

Stephen Pape	Stephen Pape	1/19/20
Adviser	Signature	Date
Dr. Pete M [illegible]		1/17/20
Committee Member	Signature	Date
Carey Borkoski	Carey Borkoski	1/19/20
Committee Member	Signature	Date
Committee Member	Signature	Date

Preface

I have spent over 15 years in public education and have witnessed many changes implemented by policymakers intending to improve instruction. My own instructional practices, as a social studies teacher, have constantly evolved to the point that I have earned a reputation for creating a rigorous but enriching learning environment where students produce evidence of their learning rather than regurgitate information on a test. Standardized tests consistently validate this learning environment. Yet when I explain to other teachers about what my teaching partner and I do, I have been told that such practices could not work in other subjects or at other schools. I entered the doctoral program at Johns Hopkins intending to understand the process of instructional change and how I could help enact change beyond my classroom. I have come to understand the complexities of teaching and feel far more confident in my ability to support fellow educators to navigate the oft rough waters of instructional change.

This dissertation marks an end to this initial process, having researched and studied the problem at the micro and macro levels and produced my own results to share with the academic world. It also marks, however, a transition as I leave the academic environment and return my full attention to how I can lead instructional changes within public education. When I entered the doctoral program, my cohort was told that our work would be difficult but would help us prepare to be leaders in educational change. Having completed this journey, I could not agree more with this assertion.

Acknowledgments

I am forever indebted to a host of people who guided me through the roller coaster process of identifying my problem of practice, designing and executing my study, and writing the full dissertation. My teaching colleagues have been more supportive than I had any right to expect. Dr. Pete Getz, the principal at my school, has proven to be both an exceptional mentor and good friend through this process. He not only guided me through the school and district politics that were necessary to make this study happen but also intervened when my stress led me to unhealthy habits and reminded me to slow down and focus on what matters most in life. I am grateful that he served as both my executive sponsor for the doctoral program as well as a member of my dissertation committee. Dr. Carey Borkoski also provided immeasurable support, both as an instructor and as a member of my committee. She not only supported me whenever I had a question about my quantitative data but also challenged me to be a better researcher. I am grateful for her friendship and guidance.

It has been a privilege to have Dr. Stephen Pape serve as my advisor and guide me through this journey. I am keenly aware that our four years together has been a challenge for both of us, as my stubbornness and early writing habits (sorry for all of the commas!) drove him crazy. I am grateful that he stuck with me, however, and helped me to become the writer that I am today. As hard as he has driven me, I know that his guidance has profoundly changed me and helped me to evolve into a more confident researcher and writer as well as a leader prepared to enact change in our world.

I am eternally grateful to my wife Brandi for her love and support through this journey. She did not apply for the job of wife to an overworked and, for a while, rather crazy person. The ups and downs that I experienced through this process were at least as hard for her as they were

for me as she struggled to understand what I was going through and provide for my ever-changing needs while also helping care for our children. Nevertheless, she shared this experience and her love with me unconditionally. I can never express my love and gratitude fully for her dedication to me and my dreams.

Finally, I am grateful to my children for their constant love and patience. Abigail was three and Lincoln was just about to turn two when I started this voyage and they have had to live with regular requests to "leave Daddy alone while he works on his dissertation." Though I tried hard to be a full-time dad in addition to being a teacher and a doctoral student, inevitably I sacrificed some time with them to get this study completed. While our youngest child, Zoey, was born while this study was in process, her smiles have added to those of her siblings and helped me to push through and complete the final edits to bring this dissertation to life. It is to my children, as well as to my students, that this dissertation is dedicated.

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Executive Summary

Computers and the advent of the internet have reshaped many of the political, social, and economic systems in the world. These changes have led to repeated calls for technology to be embedded within the learning process in American schools in order to prepare students for their future economic and social lives beyond high school. While this push has led to near universal access to computers and the internet in American schools, these technologies are often used as substitutes for traditional practices rather than as agents to transform the learning process (Thiele, Mai, & Post, 2014). The integration of computers and multimedia tools to drive student-centered learning (SCL), including collaboration and the use of authentic tasks, are the bedrock of technology-enhanced learning (TEL) practices that best support student learning in a digital learning environment.

This mixed methods study sought to investigate how a multimedia-based professional development program could support teacher's knowledge and beliefs about TEL and help foster the integration of such practices in teachers' classrooms. I conducted the study at a small public alternative high school in response to a needs assessment study as well as careful examination of relevant prior research. As a result of this initial investigation, I developed an intervention that included instruction in SCL practices as well participant construction of a multimedia presentation. I collected quantitative as well as qualitative data to examine changes in participants' pedagogical content knowledge and technological pedagogical and content knowledge (TPACK) and beliefs as well as to observe the extent to which technology-enhanced practices were integrated into their instructional practices.

Needs Assessment Study

Inspired by Bryk, Gomez, Grunow, and LeMahieu's (2015) encouragement to take a systems level approach to understanding the problem and use disciplined inquiry to drive improvement, I reviewed the literature related to TEL as well as conducted a needs assessment study prior to designing an intervention. This process was guided by Ecological Systems Theory and a sociocultural approach to learning. Ecological Systems Theory (Bronfenbrenner, 1979) establishes a model for understanding the interrelationship of influences on an individual and their contextual environment. This model is structured as concentric layers around the individual. At the most peripheral level, the macrosystem involves the overarching social and cultural factors that influence the individual. More proximally, the exosystem includes environments that indirectly affect the individual while the mesosystem focuses on the interactions that connect two or more settings within the system. Finally, the microsystem includes the environment that most immediately surround the individual. In the context of TEL, therefore, the political and social pressures that are externally exerted on schools exists at the macrosystem level while the school site, in this case a small school, serves as the exosystem. The status of the school as a high performing school elucidates the connections that exist in the mesosystem and the knowledge and beliefs of teachers exist at the microsystem. Finally, this initial investigation also considered student factors, the center of the system, that influence the adoption of technology-enhanced practices.

The interactions within each layer of the system were further enhanced through the use of a sociocultural lens. This theory emphasizes the social and cultural interactions that shape the learning environment and in which learning is situated in a community (Lave, 1996; Vygotsky, 1978). Within this community, the use of mental tools, cultural mediation, and an understanding of the zone of proximal development serve to scaffold learning and enculture students into the community of learning within the school. Identifying these forces within the ecological system helped me to illuminate the interactions that support or create barriers to TEL.

Using these frameworks as a guide, I examined studies relevant to each layer of the system for insight into the factors that support or hinder the implementation of TEL. At the macrosystem level, I noted that schools respond to external pressures to reform by adopting accepted norms that leave the instructional environment unchanged (Diamond, 2012; Meyer & Rowan, 2006). Cuban, Kirkpatrick, and Peck (2001) as well as Capo and Orellana (2012) observed that this was especially true with regards to technology integration. Teachers frequently use technology to replace their existing practices, such as using a digital slideshow instead of notes written on a blackboard to guide a lecture, rather than transform their practices. Donnelly and Sadler (2009) and Pederson and Liu (2003) similarly reported how schools and educators perceived accountability mandates as limiting their ability to enact instructional change, especially if those changes did not align directly with standardized tests.

My review of the literature also identified how the design of the target school (i.e., a small school), the exosystem in this study, creates buffers against instructional changes. Carter and Keiler (2009), for example, found that small schools often place additional burdens on teachers in the form of leadership responsibilities while offering little support or guidance on curriculum. Garth-McCullough (2007), meanwhile, found that small schools have greater distance from the scrutiny of district administrators and insulate them from broader reform efforts. This is especially true in high performing schools such as the target school. Debray (2005) and Carolson and Patterson (2015) both examined classroom practices in schools where students performed well on standardized tests. They found that past success created a barrier to change as teachers and administrators worried that integrating new practices, even those already found to support student learning, would negatively impact their test scores. Thus, at the level of the mesosystem, the success of the school created barriers to significant instructional changes.

At the microsystem level, my review revealed the importance of teacher knowledge, especially TPACK. A series of studies by van Driel, Verloop, and de Vos (1997), Meijer, Verloop, and Beijaard (1999; 2001) and Verloop et al. (2001) reported how heightened pedagogical content knowledge supported teachers in adapting their instructional practices to student needs and making larger-scale changes to their pedagogical practices. Palak and Walls (2009) further demonstrated that the attitudes teachers hold toward technology shape how that technology is used in instruction. Dole et al. (2016) meanwhile found that teachers feel a loss of control when introducing SCL pedagogies, which fundamentally changes their relationship with students. Additionally, I noticed how teacher attitudes and beliefs, especially their sense of efficacy, played a significant role in their willingness to adopt new instructional practices. Dunn and Rakes (2010), for instance, reported how teachers' heightened learner-entered beliefs and sense of efficacy supported a perception that technology integration would support student learning.

Based on these findings, I developed a needs assessment study to investigate the teacher and student factors related to TEL at the target school. I collected data from 12 teachers and 284 students using secondary data from a school technology survey conducted by Brightbytes Inc., two survey instruments created for the study, and interviews and classroom observations with six teachers. The findings revealed that although most students and teachers perceived that technology-enhanced practices were already integrated into classrooms, observations and interviews revealed that most practices were teacher directed in nature and that technology was most often used to support these traditional practices. Further, I noted that teachers felt unsure of what SCL practices were and desired to understand better how technology could be integrated to support such practices. Finally, teachers reported concerns about how technology integration would impact their role as a facilitator of knowledge as well as a lack of confidence in their ability to enact instructional changes within their classes.

Theoretical Framework

Based on the findings from the needs assessment study, I reviewed literature focusing on supporting teacher knowledge and beliefs toward the integration of technology-enhanced practices. This review was guided by two theoretical lenses, including the ecological framework for TEL developed by McKenney, Kali, Markauskaite, and Voogt (2015). Grounded in situated learning and information processing theories, this ecological model emphasizes three strands of research on design: powerful design heuristics, teacher-design consciousness and experience, and realistic understanding of design practices. As such, it identifies a design knowledge base that includes an understanding of the instructional practices that best support learners and their needs within a subject area as well as how to integrate multimedia technology to effectively support SCL. It also considers teacher beliefs toward digital technology as well as toward student-centered practices. This knowledge base thus identifies the aspects of teacher cognition that enable instructional design with technology.

To better understand how to deliver content within a TEL environment as well as guide the design of the intervention, I applied Mayer's (2001) Cognitive Theory of Multimedia Learning as a second frame for this investigation. Grounded in the dual-memory model of information processing, constructivism, and cognitive load theory, this model stresses how people learn more effectively from a combination of graphics and words rather than through words or images alone. At the same time, care must be taken to scaffold content and remove or reduce inconsequential information in order to reduce the learners' cognitive load. From these considerations, Mayer (2009) identified three main goals of multimedia learning: reducing extraneous processing, managing essential processing, and fostering generative processes. These principles provided me a framework for investigating the best multimedia tools to guide learning within the intervention as well as considering how teachers can actively construct their knowledge through observing and using multimedia tools.

Synthesis of Relevant Research Literature

With both theoretical frames in mind, I reviewed the relevant research on teacher professional development as it related to technology integration, SCL, teacher TPACK, and teacher attitudes and beliefs, especially their sense of efficacy. I observed how teacher learning is often forgotten within the context of teacher professional development (Grossman, 1990; Putnam & Borko, 2000) and that teacher learning is enhanced when teachers are active participants in the learning process (Garet et al., 2001; Opfer & Pedder, 2011). More specifically, Coenders and Terlouw (2015) reported how teachers found greater value in professional development that included activities directly related to their professional practice. These studies added weight to specifically targeting changes in participants knowledge and beliefs within the intervention as well as to involve them in tasks that they found authentic to their instructional practice.

I also noted the need to include active learning in the intervention to impact teacher knowledge. Doering et al. (2014), in an examination of middle and high school social studies teachers in a multimedia environment, found that teachers needed to be active participants with digital technology to effectively build their technological knowledge base. Allan et al. (2010) similarly found that when teachers worked with technology in a collaborative manner to address an authentic learning problem, they increased their knowledge with both technology as well as

SCL. Finally, results from a randomized control trial conducted by Minor et al. (2016) demonstrated the need for teacher professional development to focus on content that was engaging, relevant to teachers' pedagogical practice, and which they had some prior knowledge to build upon.

My examination of the literature further supported the importance of using technology-based tasks that are authentic to teachers. Karolčík et al. (2016), for example, reported on the impact that a three-year PD program on instructional technology implemented by the Slovakian government had on the beliefs and attitudes of 342 biology teachers. They found that teachers reported the greatest changes in their perceptions toward technology integration in instruction from a set of guided activities that focused on biology content. Palak and Walls (2009) similarly found in a survey of 118 teachers who had been part of a PD program offered by the Benedum Collaborative Professional Development Schools that teachers demonstrated the strongest improvements toward technology-enhanced practices when they were engaged in student-centered activities. They also reported how collaboration focused on these tasks helped to make the PD engaging and supported improvements in teacher general attitudes toward technology integration. I further noted the importance of collaboration in a study by Kellerer et al. (2014) with 900 teachers in Idaho who participated in online PD. These authors found that collaborative support helped improve teachers' confidence in their ability to integrate TEL in their classrooms. Similarly, Pan and Franklin (2011), who conducted a national survey of 559 in-service teachers investigating how the use of Web 2.0 tools impacted teachers' sense of efficacy toward instructional technology, found that collaboration on authentic tasks supported their self-efficacy in using digital tools to support student learning.

The studies identified here, along with others, offered me guidance on the design of a teacher professional development program to support changes in teacher knowledge and beliefs toward TEL along with its implementation in teachers' classes. They suggested that I needed to help participants build a deep conceptual knowledge base with regard to technology use and SCL. They also indicated the importance of fostering collaboration amongst teachers at all levels of the study, encouraging them to share their thoughts and experiences so as to minimize barriers to TEL and build their sense of confidence toward changing their instructional practices. Finally, these studies consistently demonstrated the importance of having teachers engage in authentic tasks with digital technology to build both their knowledge and sense of confidence toward technology-enhanced practices.

Study Design

The purpose of the study was to investigate the extent to which a multimedia professional development program, with instruction in student-centered practices, could change teachers' knowledge and beliefs toward TEL and support the implementation of such practices in teachers' classrooms. Ten teachers at the target school participated in the study, and four agreed to serve as case study participants for classroom observations. The study used a convergent mixed-methods design (Creswell & Plano Clark, 2011), and research questions were aligned with the outputs, measures, and near-term outcomes of changes in teacher knowledge and beliefs as well as distal outcome of TEL integration. Process and outcome evaluation measures were used to assess the intervention and fidelity of implementation.

Research Questions

RQ1: Was the PD program implemented with fidelity, including program adherence, dosage, quality of instruction, and participant responses?

RQ2: What changes in knowledge do participants evidence with regards to SCL practices, presenting content through different forms of multimedia technology, using digital multimedia technology to facilitate SCL practices, and using SCL practices and multimedia technology to facilitate student learning within their content area?

RQ3: What change in attitudes and beliefs do participants exhibit with regards to SCL, digital technology as an instructional tool, and their sense of efficacy toward TEL instructional practices?

RQ4: How do participants implement TEL practices within their instructional practice?

Intervention

The intervention was composed of two stages. In the first stage I introduced participants to the SCL principles of collaboration, authentic tasks, and student reflection. I delivered each lesson through a different multimedia presentation that was between five and ten minutes long. Following each presentation, I gave approximately ten minutes for participants to ask questions about the SCL principle that was the focus of the session before collectively evaluating the presentation using Mayer's (2009) cognitive theory of multimedia learning as a framework. During the second stage of the PD program, I asked participants to apply their learning from the first stage by creating their own multimedia presentation. In modeling elements of SCL, I encouraged participants to collaborate on this presentation and chose the modality they would use to create the presentation. I set aside three sessions for the creation of the presentation, one each for brainstorming, storyboarding, and getting peer feedback on their storyboards. When their presentation was finished, I encouraged participants to show their presentation to their classes prior to the final data collection.

Data Collection and Analysis

I collected data related to the evaluation of participant perceptions, experiences, and involvement in the proposed program from field notes, exit surveys, and focus group interviews given at the start and conclusion of the program. To evaluate the success of the program, I collected quantitative data through a modified version of the Teaching Teachers for the Future TPACK survey (TTF-TPACK), originally developed by Jamieson-Proctor et al. (2013), as well as a TPACK Survey constructed for this study. The TPACK Survey also provided qualitative data for the program evaluation as did the focus group interviews and observations from the case study participants classrooms.

Owing to the limited sample and population sizes, I used a Wilcoxon signed-rank test analyze pre and post differences on the TTF-TPACK survey and the scaled responses from the TPACK survey. I also reported descriptive statistics including frequencies, means, and standard deviations for all quantitative measures. Qualitative data were analyzed through iterative cycles of coding with thematic codes (Braun & Clarke, 2006) related to SCL practices, types of TPACK-related knowledge, and attitudes or behaviors as initial codes with an eye to emergent themes.

Findings

Pre- and poststudy data from the TTF-TPACK, TPACK Survey, focus group interviews, and observations in case study participant's classrooms suggest that most participants reported changes in their knowledge of TEL. These changes include new understandings of SCL practices, how to use multimedia technologies to deliver content to students and support instruction. The differences were most pronounced among the mathematics and social studies teachers as well as three of the five English teachers. The two science teachers exhibited fewer changes as a result of holding a strong understanding of SCL as well as how to use multimedia technology to communicate with students and drive instruction.

Pre- and poststudy analysis of the TTF-TPACK survey identified no statistically significant differences in teachers' perceptions of the usefulness of TEL practices but a significant change in their sense of efficacy toward TEL. Additionally, participants reported statistically greater confidence in their ability to use the specific multimedia tools on the TPACK Survey. Qualitative sources suggest that participants perceived fewer barriers to implementing TEL practices and saw greater affordances from these practices at the end of the intervention than they did before the intervention began. They also support the conclusion that participants generally gained greater confidence in using technology as well as in integrating TEL practices.

Finally, observations in case study participant's classroom revealed a shift in the instructional practices of three of the four case study participants. These observations generally identified a change from teacher-directed instruction in the first lesson to practices consistent with TEL in the final observation. When I discussed these lessons with the case study participants following the observations, however, it became clear that most of these changes were the result of intentional scaffolding or prior professional development experiences. Therefore, while there is some evidence that the intervention supported participants to integrate multimedia tools within their instructional practice, it appears to have had little impact on the pedagogical practices that teachers implemented within their lessons.

Chapter One

Introduction to the Problem of Practice

Our world has faced unprecedented changes over the past century. Technology has made it faster and cheaper for people to communicate, trade, and travel around the world, effectively revolutionizing the global marketplace (Friedman, 2007). In addition to transforming the global economic environment, the internet has also transformed the social lives of almost everyone on the planet (Zhao, 2015). These rapid transformations pose significant challenges for educators as we seek to promote the skills and competencies that all students will require to be successful in the 21st century.

Learners of all ages should be prepared to navigate the 21st century global marketplace and function in a globally connected social and political environment (Bybee & Starkweather, 2006). Colleges and businesses, today, are demanding high school graduates who can solve complex problems meaningful within our contemporary world, collaborate efficiently with others on these problems, and effectively communicate their opinions on these issues (Boix Mansilla & Jackson, 2011). The National Education Technology Plan (U.S. Department of Education, 2016) has called for a transformation of the learning environment to support these new skills, with a focus on five essential areas: learning, assessment, teaching, infrastructure, and productivity. The learning environment that would support such tasks needs to incorporate technology in a manner that supports a student-centered learning (SCL) environment (Lee & Hannifin, 2016).

Although technology integration has received considerable attention since the late 1970's, the advent of the Internet along with its impact on global markets and social relations has prompted an emerging consensus that technological integration is a fundamental component of education in the 21st century (Bybee & Starkweather, 2006). Much of the initial focus on technology integration centered on issues of access to technology (Culp, Honey, Mandinach, & Bailey, 2003) resulting in the investment of millions of dollars annually to ensure that every student would have access to a computer and, since the 1990s, the internet (Epstein, Nisbet, & Gillespie, 2011). Although this goal has led to near universal access to computers and the internet in American classrooms, it has done little to raise test scores or generate other notable changes in the educational environment (Thiele, Mai, & Post, 2014).

In large part, this gap between the investment in educational technology and student outcomes is explained by the role that computers have been assigned in many American classrooms. In their examination of schools that have high access but low use of computer technology, Cuban, Kirkpatrick, and Peck (2001) reported that technology is often used by teachers to support lectures and other forms of directed instruction without creating an atmosphere for students to engage meaningfully with the technology. In a similar study, Harris, Mishra, and Koehler (2009) noted that researchers continue to emphasize technology to support inquiry, collaboration, and reformed practice in classrooms despite the resistance of teachers to enact such changes. This mismatch was also identified in a 20-year retrospective on educational policies directives conducted by Culp et al. (2003). Their study identified how the U.S. Department of Education has been driven by economic considerations (i.e., that students need to use computers to be economically competitive in the global marketplace) to support technology integration as well as the belief that technology can be used to change the instructional environment away from a lecture-oriented setting to a more constructivist environment.

At the center of this pedagogical shift is the recognition that learning is most effective when students are active participants in the learning process; a process that is social in nature, centered within ill-defined tasks, and accounts for the knowledge, skills, attitudes, and beliefs that learners bring to instruction (Bransford, Brown, & Cocking, 2000; Cuban, 1983; Lee & Hannafin, 2016). Such SCL practices shift the role of teachers from a position of directing learning to supporting students as they actively construct a deeper level of understanding through active engagement with content (Brown, Collins, & Duguid, 1989; Daigle, 2000; Hmelo, Gotterer, & Bransford, 1997; Pederson & Lui, 2003).

This literature makes clear that addressing the resource needs of schools, what Ertmer (1999) identified as "first-order barriers to change," is not enough to ensure change in the instructional environment. In order for computer technology to significantly support student learning, therefore, teachers must design lessons and tasks that are student-centered in nature (Casey & Davidson-Shivers, 2014; Hannafin, Hill, Land, & Lee, 2014). Such technology-enhanced learning (TEL; Wang & Hannafin, 2005) environments have been shown to improve student motivation (Linek, Fleener, Fazio, Raine, & Klakamp, 2003) and sense of efficacy for learning (Bransford et al., 2000), increase student autonomy over learning (Grant & Branch, 2005), and promote deeper learning (Parker et al., 2013). More significantly, such practices allow students to engage meaningfully with technology in a manner that transforms the instructional environment (Cuban et al., 2001; Hannafin & Land, 1997; Theil et al., 2014; U.S. Department of Education, 2016).

Problem of Practice

The struggle to create a TEL environment is evident at California Middle College (CMC; a pseudonym), a small alternative high school in Southern California. CMC's 2015 accreditation report noted that teachers and the administration see a challenge when it comes to changing instructional practices to incorporate 21st-century skills, technology, or strategies that support

SCL. As one teacher stated "we have been used to making microwaved soup and are now being asked to make homemade stew without clear instructions" (Vanessa[*], Personal Communication, October 30, 2015).

Defining SCL Practices

Before proceeding to document the nature of the struggle to implement TEL instructional strategies, it is important to clarify how the SCL practices that are integral to TEL instruction are understood within this study. I define SCL as instruction that sees students collaborating to complete authentic tasks, requiring critical or creative thinking, some degree of personalization (i.e., student voice in the selection of the task or the way in which their message is conveyed), and that requires some reflection on students' learning within the instructional experience. As learning is a social process (Vygotsky, 1978), collaboration serves an essential role in SCL, allowing students to share ideas, debate important concepts, solidify their understanding of the content at hand, and share responsibility for the creation of a product that would be difficult or impossible for them to construct alone (Brown et al., 1989; Grant & Hill, 2006; Land & Hannafin, 1996; Pederson & Liu, 2003). This is especially important when the task at hand involves the construction of a project using technology (Lee & Hannafin, 2016; Pederson & Liu, 2003) or when learners are constructing their learning in an online environment (Ballard & Butler, 2011; Lawton et al., 2012).

One of the criticisms directed toward problem-based or inquiry-based instructional practices, examples of SCL methods of instruction, is that teachers often provide artificial structures in the form of narrowly defined tasks or extensive explanations about the problems

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[*] All personal names used in this study are pseudonyms.

that serve to distance the task from those found in the real world (Barron & Darling-Hammond, 2008; Edens, 2000; Koheler & Mishra, 2005). Authentic tasks, in contrast, are often ill defined, requiring a greater degree of cognitive effort and careful scaffolding on the part of the instructor to provide just enough support while still allowing students to struggle with the complexity of the problem and thus develop a deeper understanding of the content associated with the task (Bransford et al., 2000; Grant & Branch, 2005; Hmelo-Silver, Duncan, & Chin., 2007). By their nature, these tasks are inquiry-based requiring students to use critical thinking skills that develop a deeper understanding of content (Bransford et al., 2000; McCombs, 2001). At the same time, these tasks ask students to engage in creative thinking about novel problems that have no obvious or simple solution (Daigle, 2000; McCombs, 2009). Finally, these tasks are made more meaningful when they are focused on topics that are directly relevant to students' lives or that students themselves have a voice in identifying (Daigle, 2000; Hmelo et al., 1997).

Inspired by the research on self-determination theory (Ryan & Deci, 2000) advocates of SCL have redefined the concept of personalized learning, long described as instruction in which care is taken to create a unique learning environment for each students' individual needs, toward the inclusion of student voices in the selection of topic, the construction of the task, or the means through which the resolution of the task is presented (Daigle, 2000; Grant & Branch, 2005; Hmelo et al., 1997; Lee & Hannafin, 2016). Providing such personalization creates a stronger motivation for the student to engage with and complete the task, gives the task a great degree of authenticity, and supports a higher rate of cognitive transfer (Daigle, 2000; Hmelo et al., 1997; Lee & Hannafin, 2016; Schmidt, Loyens, van Gog, & Paas, 2007).

Finally, student-centered practices engage students in meaningful reflection about the tasks they are engaged in and how those tasks impact their thinking (Daigle, 2000). The metacognitive practice of reflecting on the learning experience helps to solidify the learning of both declarative and procedural knowledge during the course of instruction within SCL (Creedy & Hand, 1994; Grant & Branch, 2005; McCombs, 2001). By pausing to reflect upon what they have learned, students consider more broadly the nature of the learning in which they are engaged, identify areas in which they need to foster further development, and develop a deeper conceptual understanding of the knowledge with which they have engaged (Lee & Hannafin, 2016; McCombs, 2001; Pederson & Liu, 2003).

Thus, SCL practices are defined by student collaboration in tasks that they have a voice in determining, are authentic to students' context, and require them to actively reflect on the learning process. Such practices have been shown to promote a greater degree of student learning than traditional directed instruction alone (Bransford et al., 2000; Hmelo et al., 1997; Lee & Hannafin, 2016); however, directed instruction provides a critical scaffold that allows students to succeed in these complex tasks (Hmelo-Silver et al., 2007; Schmidt et al., 2006; Woo & Laxman, 2013).

Despite the growing prominence of SCL practices (Lee & Hannfin, 2016; Zmuda, 2009) critics have raised concerns that such practices fail to adequately support students in the learning process. Kirschner, Sweller and Clark (2006) argued that minimally guided instruction fails to account for the human cognitive architecture, depriving students of the needed experience to develop expertise and ignoring the limits of working memory, thus creating cognitive overload that prevents meaningful learning from occurring. Sweller (1994) further argued that the skills needed for discovery, active learning, and problem solving must be explicitly taught. Similar to Kirschner et al. (2006), Casem (2006) argued that instruction focused on active learning ignores the need for frequent assessment and feedback to guide the learning process. Mayer (2004) similarly raised concern that instructional practices that are based solely on "discovery learning" present an extreme view based on the fallacy that there is only one way in which learning occurs.

In response to these concerns, Hmelo-Sliver et. al. (2007) noted that most research on SCL practices is based on the premise of scaffolding as a central component in the learning promise. From this perspective, direct instruction serves a central role both at the outset of instruction and throughout the development of the active learning process through just-in-time instruction (Brown, 2002; Hmelo-Silver et al., 2007; van Gog, 2014). Schmidt et al. (2006) further argued that SCL practices, such as problem-based learning, cannot be considered minimally guided as they rely on essential cognitive process such as activation of prior knowledge and elaboration. In short, the characterization of student-centered practices as "minimally guided", "pure discovery", or purely based on inquiry misconstrues the cognitive principles upon which SCL is based (Lee & Hannafin, 2016; Mayer 2004, 2009; Schmidt et al., 2006; Woo & Laxman, 2013).

Though evidence that the adoption of SCL practices and the meaningful integration of technology helps to promote student learning and achievement, the teachers at CMC are hesitant to use digital technology to facilitate student-centered approaches to learning. Evidence suggests that teachers see such changes as foreign or intrusive as characterized by Zhao and Frank (2003). They also identified a need for greater knowledge related to TEL practices (Rohann, Taconis, & Jochems, 2012) and were concerned about their abilities to integrate technology or student-centered instruction (Abbott, 2005; Hannafin et al., 2014). Similarly, students who have been acculturated to a system based on performance through standardized tests are suspicious of strategies that promote personalization, inquiry, and reflection (Becker, 1994; Hsieh, Cho, Liu, &

Schallert, 2005; Perlman, 2010). For these reasons, classes at CMC often do not integrate digital technology as a means of creating a TEL environment that supports 21st-century learning.

The need to use disciplined inquiry to fully investigate a problem before taking actions is central to reforming practices within education (Bryk, Gomez, Grunow, and LeMahieu, 2015; Perla, Provost, & Perry, 2013). To that end, this chapter examines my problem of practice more deeply through a review of the literature related to instructional change, particularly within a small school environment. Guided by ecological systems theory (Bronfenbrenner, 1979) and sociocultural learning theory (Vygotsky, 1978), the chapter identifies factors that create barriers to TEL integration from the most peripheral level (i.e., the social pressures exerted upon schools by policy makers) to the most proximal (i.e., the knowledge, attitudes, and beliefs that teachers and students bring with them into the instructional environment). Through this examination, the factors related to teachers' knowledge, attitudes, and beliefs are identified as those most pertinent for further examination at CMC and guide the development of a needs assessment study (see Chapter Two).

Theoretical Framework

Guiding this examination of the literature related to TEL integration are two lenses that help create a frame for investigating the factors that facilitate or inhibit instructional changes associated with SCL and technology integration, particularly within small schools. An ecological systems perspective (Bronfenbrenner, 1979) is first used to organize the underlying factors related to the learning environment. A sociocultural lens is then applied to help understand the relationships between the factors, especially as they relate to the students and teachers within the learning environment. Together these theories provide a foundation for examining the institutional and classroom factors that support TEL integration.

Ecological Systems Theory

Bronfenbrenner (1979) initially developed Ecological Systems Theory (EST) as a model to explain human development. It established a central role for the individual with nested layers of influences surrounding him or her, illustrating the role that cultural and environmental context plays in a child's development. As such, researchers view the model as a scientific approach to the interrelationship of different processes and their contextual environments (Darling, 2007). This systematic framework makes EST a valuable tool for both understanding and investigating problems within education (Zhao & Frank, 2003; Resnick, 2010).

Bronfenbrenner (1979) conceived this model as a ring of concentric circles nested around the individual, similar to a Russian nested doll (i.e., matryoshka doll). His initial model included four layers of systems: the microsystem described the environment directly surrounding the child, including home, school, and community; the mesosystem focused on the connections between immediate environments such as between the child's parents and teachers; the exosystem included factors in proximal environments that indirectly affect the child (e.g., the parent's workplace); and, finally, the macrosystem included the overarching social and cultural values that impacted the child (e.g., their ethnic status or the concept of the rights of children). Later, Bronfenbrenner (1993) added the chronosystem to the model to indicate the impact of time on all aspects of the system and the development of the child. At this time Bronfenbrenner also introduced the concept of "proximal processes," progressively complex reciprocal interactions between a person and his or her environment. This later became the basis for his bioecological aspect to the model with the child's biology as a critical aspect of the microsystem (Bronfenbrenner & Morris, 2006).

The nested system model has been applied to several areas of education. Resnick (2010) advocated the use of a nested learning system to support and expand understanding of knowledge and student performance, what she termed the Thinking Curriculum. Hunt, McDonald, and Crockett (2012) used Bronfenbrenner's EST model to support their critique of applying standards-based measures to special education populations and concluded that such accountability measures ignore the context of student development, especially for disadvantaged populations. More germane to this current study, Zhao and Frank (2003) used EST to explain the resistance to technology integration evident in American schools. Their model conceived the elements of the classroom (including students, teachers, computers, etc.) as different species in the same ecosystem. Computers, as the newest addition to the ecosystem, acted as aggressive species that threatened the balance within the ecosystem. One reason for this disruption (i.e., that teachers have been slow to adopt technology in the classroom), they concluded, is that the aggressive policy campaign to make computers a central feature of the learning environment was rarely complemented by meaningful support or direction. This lack of support left teachers unsure and frightened of the role of technology in instruction, much the same way established creatures view the arrival of a new aggressive species in their ecological niche (Zhao & Frank, 2003).

Recent advances in technology have prompted some scholars to propose modifications to Bronfenbrenner's nested model. Johnson and Puplampu (2008) proposed the inclusion of a techno-subsystem to Bronfenbrenner's model, identifying the internet as a mediating agent between the child and its microsystem. Similarly, noting the growing influence of social networking, Neal and Neal (2013) proposed a networked systems model, dismissing the concept of a nested doll for the connected diagram of a circuit to more clearly identify the interactions between elements of the systems.

To date, however, neither has been used to explicitly investigate the dynamics of learning or the instructional environment. Johnson and Puplampu's (2008) model has been applied to evaluate the impact of the internet on child development (Tzuo & Toh, 2015), the role of homework in parent-teacher-student interactions (Katz, Lee & Byrne, 2015), and the role of behavioral, cognitive, and constructivist theories as they are applied to online learning (Johnson, 2014) but not to examine the nature of learning in the instructional environment. Likewise, although Neal and Neal's (2013) model has been used effectively to study social network interactions in multiple institutions including middle schools (McCormick & Cappella, 2014), it has not been used to explain the dynamics of the instructional environment of the classroom and the forces that act on it externally.

The ecological framework for TEL, developed by McKenney, Kali, Markauskaite, and Voogt (2015), however, builds upon Bronfenbrenner's (1979) model to provide a lens for examining practices that support technology integration in the classroom. The model focuses on six integrated domains of design knowledge to support the integration of TEL: teachers' knowledge about technology, pedagogy, and content; the beliefs that teachers hold toward instruction; teachers' understanding of how to build their skills with technology; teachers' knowledge of instructional design sequencing; the support available to teachers and students for technology integration; and the environmental factors that influence technology integration in the learning process. This ecological organization as well as the synthesis of literature upon which this model is based create a firm foundation for examining the competencies, knowledge, and practical considerations for technology integration in the classroom (Kirschner, 2015).

As technology integration is central to this current investigation, EST provides a conceptual structure for organizing the underlying factors associated with limited use of TEL. To understand the relationship between those factors, however, a sociocultural lens is also applied to help frame this study. This lens further informs a deeper understanding of the SCL practices that TEL is based upon, especially the role that collaboration and authentic tasks play in instruction (Daigle, 2000; Dole, Bloom, & Kowalske, 2016).

Sociocultural Perspective on Learning

While EST provides a structure for understanding and analyzing an educational system, a sociocultural lens provides the means for analyzing the interdependence of social interaction and individual processes in the construction of knowledge within that system (Billett, 1996; Vygotzsky, 1978). These processes are shaped by the student's constant interaction with his or her environment, especially the social and cultural environment (Vygotsky, 1978). Schools, in this sense, act as institutions that support novice learners in becoming part of a larger community of learning (Donato & McCormick, 1994). Critical to this process, as originally conceived by Vygotsky, are three elements: Tools of the Mind, cultural mediation, and the zone of proximal development.

Vygotsky placed a strong emphasis on the use of tools in the learning process, believing that just as physical tools extend our physical abilities, mental tools extend our cognitive abilities. Vygotsky referred to these as "Tools of the Mind" (Vygotsky, 1978). Therefore, students should be exposed to more than just facts; they also need to learn how to use tools that would extend their thinking (Donato & McCormink, 1994). Today we can see technology serving as one of the most fundamental tools needed to enhance learning, both in school and beyond (Gedera, 2014; Judson, 2010). As Bandura (2002) notes, however, "information technologies are a tool not a panacea. They are only useful to those who choose to use them productively” (p. 3).

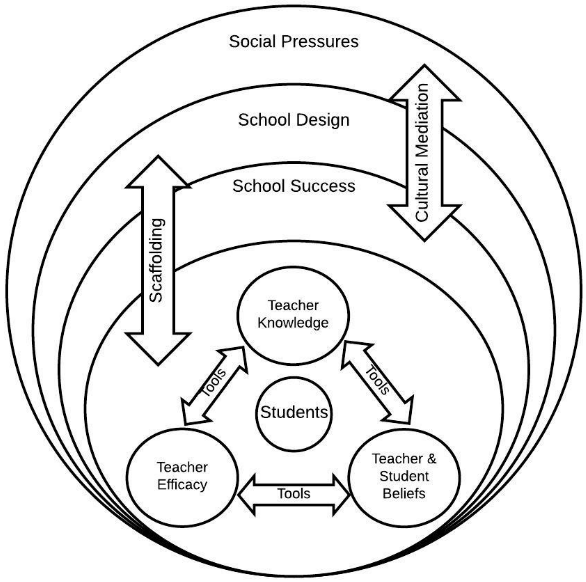
Cultural mediation also helps to explain the relationship between the classroom and the various layers of the ecological model. Cultural mediation refers to the process of social interaction by which a student learns the habits and language associated with his or her culture. It is through these cultural tools that students derive meaning, which allows them to construct knowledge (Lasky, 2005; Vygotsky, 1978). Learning is therefore situated in the cultural construct of a community of practice in which novice learners engage through peripheral participation and teachers act as experts to guide the novice into full participation in the community (Lave, 1996). As a community of practice, each layer of the instructional ecology provides support for the students and teachers at the instructional core.

Both the use of tools and cultural mediation denote a strong relationship between the individual and the environment in the learning process. Gee (2008) notes that this interaction with the environment is what creates an affordance for learning and central to this affordance is the zone of proximal development. Vygotsky (1978) identified this zone as the difference between what a person can achieve by him or herself and what he or she can do with support. The zone of proximal development can be mediated by a host of factors including teachers (Ramdass, 2012), curriculum (Kearney, Schuck, Burden, & Aubusson, 2012), and technology (Salmon, Globerson, & Guterman, 1989). Thus, each layer of the ecological model, particularly those most proximal to the classroom, can provide some form of scaffolding to support growth within student’s ZPD.

A Systems Analysis of Factors Associated with TEL Implementation

Together, EST and the sociocultural perspective on learning provide a useful framework for examining the integration of technology in the classroom as a tool for developing SCL. The model constructed here (see Figure 1.1) places both teachers and students, the actors who make up the core of the instructional environment, at the center. At the outermost layer, most peripheral to the core of instruction are the external social pressures that act on the school environment, including accountability measures and policy directives from the state and federal governments, as well as demands for greater technology and new pedagogical practices resulting from changes in the economy and social environment. Moving closer to the core of instruction, the design of the school, in the present case a small school, creates an environment that is supportive of students, creates a strong sense of community, and fosters stability. More proximal to the instructional environment in the present study is the culture of success within the school, fostered by its status as a high performing school as reflected on accountability measures. Finally, most directly impacting the instructional environment are three inter-related factors: teachers' knowledge and skills, teachers' sense of efficacy in regards to instructional changes, and the beliefs and attitudes that teachers and students hold toward new instructional tools or pedagogies.

Figure 1.1 Theoretical Framework of Factors in EST Model



According to Ertmer (1999), there are two types of barriers to the integration of new tools or ideas in instruction. First-order barriers include factors extrinsic to instruction that may serve as hurdles to creating change (e.g., resources such a computers). Second-order barriers are more intrinsic and fundamental to the learning process (e.g., the beliefs and attitudes that students and teachers hold toward learning) and often are harder to address than first-order barriers. The ecological system model laid out here provides a lens for focusing on those second-order barriers.

The Macrosystem - Societal Pressures on Education

Social pressures, including pressure from parents and policymakers to address new skills for a changing economy (Eye, Glib, & Hicks, 2013), to meaningfully incorporate technology in the classroom (Ertmer, 2005; Zhao & Frank, 2003), and to show improvement on accountability measures (Culp et al., 2003; Ingram, Louis, & Schroeder, 2004), have an indirect but meaningful impact on the instructional environment (Parci & Darling-Hammond, 2015; DeBray, 2005; Epstein et al., 2011). The relationship of these social factors to the instructional environment is equivalent to the macrosystem of Bronfenbrenner's nested systems model on the individual, defined as the social and cultural values that impact the core of the system. These values influence the interactions within a school, shaping the cultural constructs through which students construct knowledge (Lasky, 2005). An examination of this relationship reveals that teachers and administrators often respond to outside pressure by creating barriers that seek to protect the status quo at the instructional level (Ingram et al., 2004; Mehta, 2014).

Diamond (2012) noted this response to external pressure in his examination of instructional reforms in Chicago's schools. He observed that as schools faced greater pressure to reform they were less likely to change their instructional practices. This is supported by the results from studies by Meyer and Rowan (1977, 2006) who noted that schools, like other institutions, establish myths and rules that promote resistance to change. Thus, when faced with external pressures, schools tend to respond by adopting an accepted structure and set of norms while leaving classroom instruction and learning mostly unexamined (Rowan, 2006). This can be more clearly demonstrated by closely examining the external reform movements related to technology integration and SCL.

Technology integration efforts. Efforts to integrate technology into U.S. classrooms demonstrate the complexities of external pressures on the instructional environment. In 2001, Cuban and colleagues authored a seminal study on the lack of instructional change as a result of technology integration in American classrooms. They examined two technology-rich high schools in California's Silicon Valley for evidence of how often and for what purposes the technology was being used. They found that even though the teachers in both schools had ready access to computers, few teachers were actually using this technology in a manner that enriched instruction. They concluded that the number of computers that teachers had access to mattered less than the ability and desire of teachers to use that technology in a meaningful way. Thus, teachers and students were encultured into a system in which technology was used to replace existing practices rather than transform instruction. Their findings have been consistently supported in investigations into barriers to technology integration (Ertmer, 2005), examinations of how the internet (Gu, Shao, Guo, & Lim, 2015) and internet tools (Lu, 2010) are used in instruction, and studies that explored the expanding role of mobile technology in classrooms (Iqbal & Bhatti, 2015). These results suggest that schools create a culture of learning in which digital technology serves as a tool for updating existing practices (i.e., using a laptop to write an essay rather than writing it out by hand) rather than as a tool to help students construct their knowledge through active tasks.

More recently, Capo and Orellana (2012) conducted a similar investigation into the use of Web 2.0 tools in American classrooms. Noting the role Web 2.0 and social software played reshaping students' lives as well as the increasing pressure on teachers to incorporate such tools into their instructional practices, they surveyed teachers from the Miami-Dade County Public Schools regarding their use of Web 2.0 tools. One-hundred thirty-seven high school teachers completed an adapted version of the Aijan and Harthshorne Questionnaire. Despite the promise Web 2.0 tools hold for classroom integration, less than a quarter of the participants use such tools in their instructional practice. Teachers recognized the external pressure to use these tools, and over 60% felt that such tools would improve the value of their instruction. They worried, however, about their ability to exert behavioral control during lessons in which they incorporated such technology. Further, most teachers felt that the use of Web 2.0 tools in instruction encouraged an overreliance on technology amongst students, which they felt they had to actively counter in their classroom practices. In other words, these teachers felt it was their responsibility to push back against the pressure to use newer technology in order to better support student learning.

Evidence from policy makers suggests that teachers are not alone in holding complex attitudes toward technology integration. In their 20-year retrospective on policy directives from the United States Department of Education, Culp et al. (2003) identified that although most policies and reports provided concrete findings and recommendations related to technology infrastructure in schools, they tended to provide more theory than substance when it came to the use of technology as an instructional tool. Thus, the federal government was in the position of promising that technology could be a transformational agent in education without providing any real direction on how to go about implementing that transformation.

A more recent study by Epstein et al. (2010), examining evidence of the digital divide in American schools, substantiated these earlier findings. Using data from a national omnibus poll conducted by the Survey Research Institute at Cornell University, they found that the expectations of technology integration, nature and existence of a digital divide, and responsibility for addressing technology needs for students largely depended on who was framing the issue. Different actors, including educational institutions, policy makers, nonprofit organizations, and individuals all held different views. This, the authors argued, creates competing demands on teachers and schools regarding technology integration in schools. Such competing demands serve to strengthen barriers to changes in the instructional environment as teachers fear that embracing change will not be supported in the long run (Meyer & Rowan, 2012).

These findings are not universally supported by scholars investigating the integration of technology in education. Notably, Ertmer (2005) reviewed an array of factors associated with the lack of computer use in America’s classrooms and concluded that the policy environment for technology integration was very positive. As evidence, she noted the increase in funding over the past few decades, the adoption of national standards for technology and computing by the International Society for Technology in Education, the growth of block schedules in American schools, which provide more time for meaningful technology use in classrooms, and the public support for the use of computers in education by prominent members of the government, including President Clinton (Ertmer, 2005). From this evidence, she concluded that the policy environment was supportive and that it was teachers' beliefs that most accounted for the lack of technology integration in schools.

As will be evident below in a broader discussion of the literature related to teacher beliefs and attitudes, Ertmer (2005) echoed a position that is well supported by research on teacher perceptions of technology. The strength of the argument regarding teacher beliefs, however, obscures significant points about the policy environment that are still relevant. A supportive policy environment can still encourage changes that teachers find obtrusive or even hostile (Cuban et al., 2001; Meyer & Rowan, 2012; Zhao & Frank, 2003). Moreover, even policies that are overtly supportive at the state and national levels could be translated into repressive measures when mediated by district and site leadership (DeBray, 2005; Mehta, 2013; Penuel & Spillane, 2014). Students, therefore, continue to be encultured into learning communities where technology serves to replicate existing practices rather than as tools for expanding learning potential. Accountability mandates create a similar barrier to the integration of SCL practices embedded within TEL.

Impact of accountability mandates. A concern voiced by teachers in general is that moving away from directed instructional practices runs counter to their perceptions of the accountability mandates that have been established over the past two decades (Donnelly &

Sadler, 2009). In their study of 22 science teachers from five high schools, Donnelly and Sadler reported that teachers perceive curriculum standards and other accountability measures as creating hard parameters pertaining to instructional environment that promotes a narrow focus on content and rote memorization.

DeBray (2005) conducted a similar study at an urban, comprehensive high school in New York City to examine the perceptions and actions of teachers and administrators toward the implementation of No Child Left Behind policy expectations. From classroom observations and interviews with eight English and five mathematics teachers, DeBray concluded that although teachers and administrators supported the concept of accountability measures, they felt that the existing policies put in place by the federal and state governments only served to narrow the curriculum without supporting instruction.

The impact of this narrowing of the curriculum is further evident in Pederson and Liu's (2003) study of teacher perceptions toward SCL using the computer game simulation, Alien Rescue. Of the 15 middle school science teachers who participated in observations and interviews, all but one teacher indicated their reliance on curriculum standards for designing lessons. In addition, these teachers reported concern that SCL activities did not directly relate to accountability measures. In other words, despite research indicating heightened student learning in SCL environments, teachers saw such practices as distractions from preparing students to perform well on standardized tests (Pederson & Liu, 2003).

These findings were later supported by Grant and Hill (2006) who developed a framework for risks that teachers faced in attempting to implement SCL practices in their classroom. The teachers reported that they faced a variety of personal challenges to their pedagogical beliefs when seeking to implement student-centered practices. Additionally, they found that teachers often faced resistance to such practices from teacher leaders, administrators, and district officials who saw these changes as insubstantial or even harmful toward the goal of raising test scores (Grant & Hill, 2006). Together these social pressures, though outside the system of the school itself, exert considerable pressure on the instructional environment. Such pressure can be moderated or exacerbated by the proximal environment of the school, such as its design.

Exosystem - Small School Design

In a manner similar to how the social values of the macrosystem influence the proximal environment of the exosystem in Bronfenbrenner's model, the social and political pressures exerted on education influence the design of schools, including the initiative to create small schools as an alternative to large comprehensive high schools. Small schools have seen a dramatic rise in popularity over the past three decades driven by the calls for school choice, privatization, and site-based management (Garth-McCullough, 2007; Lehman & Berghoff, 2013). These schools have been largely praised for creating more personalized instruction (Lehman & Berghoff, 2013), greater student and teacher satisfaction (Carter & Keiler, 2009), and a stronger sense of community than can be found at larger comprehensive schools (Kahne, Sporte, de la Torre, & Easton, 2008). Yet these same factors can also serve to hide the fact that few small schools live up to their promise to transform the instructional environment (Lehman & Berghoff, 2013; Ravitz, 2010), and, after becoming well established, are often buffered against change due to their loose connections to district officials (Garth-McCullough, 2007; Kahne et al., 2008).

One of the oft-touted strengths of small schools is their ability to create tight and supportive communities of practice. In a study of alternatively certified novice teachers in New

York who accepted assignments at small schools, Carter and Keiler (2009) found that these claims were largely true. Using interviews and observations of nine novice teachers in separate schools, the participants revealed a strong relationship with their colleagues and students and came to value those relationships as the primary motivation for remaining at the school. However, these same novice teachers also experienced a lack of direction and support when it came to curriculum and instruction as well as an unwanted responsibility in school leadership at their sites (Carter & Keiler, 2009).

In a study of small schools in Chicago, Kahne et al. (2008) reviewed administrative records and survey results from the Consortium on Chicago School Research's biannual survey given to all students in grades 6-12 from 2002-2006. They examined the effects of school conversions, which the Chicago school system had implemented starting in 2001 with a $12 million-dollar grant from the Gates Foundation. Students and teachers found small schools to be more supportive environments compared to their counterparts at comprehensive schools. They also found, however, that instructional practices were not substantially different at the smaller schools and that there were no significant differences in the achievement rates in either school design (Kahne et al., 2008).

In light of the paucity of evidence of increasing student performance on standardized tests, Ravitz (2010) reviewed the results from the 2005 National School District and Network Grants Program National Evaluation, a survey of teachers and students conducted by the Bill and Melinda Gates Foundation, as well as the results of a survey of 395 teachers that the Buck Institute conducted in 2007. Ravitz searched for evidence that small schools promoted project-based learning, a well-known student-centered design, and how that design impacted school culture. In a measure of inquiry practices, small schools did indeed score higher in project-based learning (i.e., strategies such as portfolios or open-ended problems for assessment) compared to more traditional schools. The small school design, however, fostered a change in *teacher* culture more than it did a change in *school* culture.

The findings that Ravitz (2010) reported are not universally supported. Garth-McCullough (2007) used Hirshman's (1970) theory of declining institutions to explore teacher's experiences and their reasons for leaving or staying loyal to small schools. Her research focused on one school in the Chicago Public Schools system. She gathered data from focus group interviews with teachers, staff, and administrators as well as classroom observations. The results of this study indicate that small schools give experienced teachers a buffer from the political scrutiny of district offices and provide a strong supportive environment, which confirms the analysis of Carter and Keiler (2009) and Kahne et al. (2008). Classroom observations, however, also evidenced a lack of urgency to reform instructional practices. In effect, the distance of teachers at small schools from both district scrutiny, as well as district support and professional development (PD), can insulate the instructional environment of small schools from major reforms (Garth-McCullough, 2007).

These studies indicate that while small schools have proven successful in creating a supportive culture, they remain influenced by social pressures in a myriad of ways. Although they hold the potential for supporting significant transformations to the learning environment (Ravitz, 2010), the isolation of small schools from accountability and social demands (Garth-McCullough, 2007; Kahne et al., 2008) may help ensure a focus on traditional learning strategies. The impact of the demands facilitated by the small school design and increased societal pressures, however, depends also on how successful schools identify themselves vis-à-vis their achievement record.

Mesosystem – Exemplary School Achievement

Bronfenbrenner (1993) described the mesosystem as a system in which two or more settings interact. He gave as an example a child's interaction with both daycare and home. In considering the major curriculum changes that are inherent within TEL integration, the interaction of the school-site and the classroom are considered within the context of exemplary school achievement. Schools that identify as high performing on accountability and other measures create a culture of success that leads school leaders to accept current instructional practices and resist pressures to modify classroom practices (Knoeppel & Rinehart, 2010). This culture is extended into the classroom where practices are immune from change because students have shown success on standardized tests (DeBray, 2005). This resistance serves to narrow curriculum as well as the zone of proximal development for student learning (Hung & Der-Thanq, 2001). Thus, although societal values (the macrosystem) and the design of schools (the exosystem) provide a framework for understanding the most distant factors that impact the instructional environment in schools, factors that reside at the level of the mesosystem provide a framework for examining those factors more proximal to the instructional core.

Although the efforts to increase school achievement in low-performing schools has support from significant amounts of research literature, Carlson and Patterson (2015) note that very little work has been done on instructional change in high-performing schools. These researchers engaged school leaders from a high-performing private high school in an investigation to elucidate their perceptions of barriers to change in these schools. Through a series of open-ended surveys, focus group interviews, classroom observations, and analysis of student work, Carlson and Peterson found that past success created a significant barrier to instructional change in some staff members, especially those in leadership positions. Although novice teachers and those who had not been part of the school for long saw changes as innovative and progressive, established teachers and leaders saw such innovations as a threat to the school's culture of learning. To teacher leaders, in particular, the integration of technology or other substantive changes in the instructional environment served as an unnecessary distraction from the teaching of content that is central to student success on standardized exams. These teachers, thus, worried that such changes would lead to a decline in learning that would tarnish the reputation of the school (Carlson & Patterson, 2015).

Concerns about school performance were also the focus of a 2006 study by Grant and Hill, in their work with teachers in Georgia, Tennessee, and Kentucky. Based on the findings from one-on-one and focus group interviews, classroom observations, and surveys, Grant and Hill noted that teachers rejected or limited their application of student-centered pedagogies because they felt that such methods created a learning environment that was chaotic and did not support learning. If they adopted SCL, these teachers reasoned, students would fail to learn and the reputation of the school would be harmed. Grant and Hill, as well as Cuban et al. (2001) in their study of schools with high-access but low-use of technology, also observed significant barriers to change in the schools. Despite overwhelming evidence that such measures would benefit instruction, these studies found that existing school culture continuously responded to proposed changes by reinforcing the existing cultural norms. Carlson and Patterson (2015) referred to schools that practiced this resistance as "entrenched schools." Both of these studies suggest that student learning, in these high performing schools, was situated in a community that prioritized accountability measures and limited potential distractions from that goal, including instructional changes that are consistent with TEL.

Other literature on entrenched schools shows that external and internal perceptions within a school, such as being defined as a "successful school," tend to reinforce features of school culture. Corbett, Firestone, and Rossman (1987) reported on this aspect of school culture as they were embedded for over a month in three high schools with different demographics and histories. These authors collected data from daily observations of classes focusing on the interactions between students and adults and interviewed both students and adults. As daily participants in the school, they were able to see how schools established clear values, norms, and beliefs that are collectively held–what they referred to as "the sacred in schools."

The results from Corbett et al. (1987) corroborate previous findings by Meyer and Rowan (1977) on the role of myth in shaping institutional culture and Day's (2002) study on the impact of accountability measures on teacher professional identity. In each example, the teachers had developed a clear and collective identity that was embodied in shared norms and values. Changes that seemed to impact those values, especially at the instructional core of the school environment, threatened to disrupt the system as a whole. When a defining feature of these values is the past success of the school, any substantive changes to the instructional environment may be viewed as hostile to the cultural identity of the school itself. In the case of CMC, this school culture is embedded within the design of the school as a small school and helps to define the barriers most proximal to the instructional core: teacher knowledge, teacher efficacy, and teacher and student perceptions of instruction.

The Microsystem – Teacher Cognition

What teachers know, believe, and think constitutes a form of cognition that frames their instructional practices (Borg, 2003). These factors are interrelated and work together to form a "web of influence" that impacts their teaching practice (Neumann, 2016). This web of factors creates the lens through which teachers understand their environment and cope with any external factors that place pressure on that environment (Neumann, 2016). It, thus, shapes the role that teachers play in guiding student learning within a community of practice as well as the tools that they use to support student learning within the zone of proximal development. Teachers' knowledge, beliefs, and attitudes, therefore, form the microsystem of the instructional environment and more directly influence the direction of learning than any other system of factors in the ecological model of the instructional environment.

Teacher knowledge and skills. The knowledge and skills that teachers possess create a "knowledge base for teaching" (Shulman, 1987, p. 5) that shapes the learning environment (Grossman, 1991). Although teachers have always been expected to be knowledgeable about the content in which they will instruct students, recent decades have also seen an increased concern that teachers maintain a high level of pedagogical knowledge (PK) (Verloop, Van Driel, & Meijer, 2001). This concern, consequently, shapes recommendations for teacher PD (Hiebert, Gallimore, & Stigler, 2002) and education (Verloop et al., 2001) as well as educational policy directives (Henderson, 1988).

In his seminal works on teacher knowledge, Shulman (1986; 1987) argued that we have focused too much on teacher content knowledge (CK) and not enough on teacher PK. Taking an historical perspective on teaching, Shulman (1986) examined the tests required to become a teacher in the late 1800's noting that they focused on "the how of teaching" rather than "the what of teaching" (p. 3-4), while most current teacher examinations focus exclusively on content. Arguing that the professionalization of teaching focuses on a "knowledge base for teaching" comprised of both CK and PK (Shulman, 1987, p. 4), he recommended that teacher training focus on a model of pedagogical content knowledge (PCK) in which the two types of knowledge are understood as interdependent (Shulman, 1986). PCK emphasizes the transformation of subject material as the teacher interprets it, finds multiple ways to represent it, and adapts instructional material to students' prior knowledge (Koehler & Mishra, 2009). Although some have argued that Shulman's model of teacher knowledge is too assessment driven (e.g., Sockett, 1987), the PCK model has received wide approval by educational researchers (Henderson, 1988; Neuman, 2016; Rohaan, Taconis, & Jochems, 2012).

The role of PCK in teaching has led scholars to investigate more fully other types of knowledge that are central to teachers' understanding and to shaping the learning environment. Grossman (1990) designed a model of teacher knowledge with four domains: subject matter knowledge, general pedagogical knowledge, knowledge of the context, and PCK. She then used this model in a case study of six novice English teachers, investigating how the coursework in their teacher preparation program impacted their PCK. Data collected from interviews and classroom observations revealed that those who attended strong preparation programs held beliefs that supported their practice and their willingness to experiment with new texts and practices, while those from weaker programs relied more heavily on traditional texts and curriculum guides (Grossman, 1991).

Teacher instructional knowledge was also the subject of a series of studies by a team of researchers from the Netherlands. The initial study by van Driel, Verloop, and de Vos (1997) involved a review of the seminal research on teacher craft knowledge including Shulman (1987), Grossman (1990), Marks (1990), Chochran et al. (1993), and Fernández-Balboa and Stiehl (1995). This review identified two elements that were prominent within each conceptualization of teacher knowledge: knowledge of teachers about specific conceptions and learning difficulties with respect to their content as well as knowledge of teachers about representations and teaching strategies within their content. The authors then validated these findings in a qualitative study with 12 chemistry teachers. Using a grounded theory approach and focusing their attention on the topic of chemical equilibrium, they collected data from audio recordings of a workshop that participants attended, recordings of two lessons in each participant's classroom, and written responses to student work. They noted how participants were flexible in the approaches they took toward presenting chemical equilibrium to students based upon student prior knowledge and comfort with scientific knowledge as well as how they were able to transform their knowledge to meet student needs.

Meijer, Verloop, and Beijaard (1999; 2001) built upon these findings in their study of practical knowledge of language teachers. Their research included an initial qualitative study of 13 high school foreign language teachers, and a follow-up, quantitative study involving 69 high school foreign language teachers. The initial 1999 study sought to define shared practical knowledge base among language teachers through semi-structured interviews and a guided concept mapping assignment. The results from this study revealed a diversity in teacher's practical knowledge and led the authors to abandon the search for shared knowledge and instead create a typology of three forms of teacher practical knowledge including subject matter knowledge, student knowledge, and knowledge of learning.

Based on these findings, Meijer and colleagues (2001) returned to the question of the similarities and differences in teacher practical knowledge in a questionnaire designed for the study. The questionnaire included 136 Likert-style questions grouped within six categories of teacher practical knowledge that were originally considered in the 1999 study. The data were initially analyzed by separately examining each category of practical knowledge to identify items of low variance, which would indicate evidence of shared knowledge. Correlations between remaining items in each category were calculated and a principal components analysis was conducted to investigate the structure of the items within the category. Items where the proportion of variance was 0.45 or higher were maintained for a second principal components analysis to identify the variance in teacher practical knowledge by examining the relationship between the categories. As in the first study, the authors could not define a significant shared knowledge base in teacher practical knowledge. They did, however, identify four scales of practical knowledge in language instruction: importance, student difficulties, students and texts, and segments of reading comprehension. They then performed a cluster analysis using linkages on the teachers' scores on the four scales and identified four types of teachers within the study. One group emphasized the larger elements of teaching reading comprehension, and another held a segmented view (i.e., the emphasized the small elements of reading comprehension). A third group of teachers emphasized reading comprehension by relating texts and students, and a final group had a low appreciation for reading comprehension.

Finally, Verloop et al. (2001) reviewed the results of these previous studies and conducted a phenomenological study with 60 teachers of first-year engineering students to examine how teachers conceive of their knowledge and instruction. Data were collected through focus group interviews and used to identify three conceptual categories of teacher knowledge: student-directed, teacher-directed, and student-centered. The most common teaching conception was student-directed in which students are supported as much as possible through explanations, presentations, and feedback, but in a regulated setting that allows for a fixed amount of content to be presented efficiently. The conception that the authors labeled as teacher-directed, on the other hand, reflected a perception of the teacher as an expert in the subject matter who, rather than supporting students, corrects student's misconceptions and encourages them to study hard.

Although teachers who hold the student-directed conception of teaching were more likely to provide personalized support to students, both student-directed and teacher-directed conceptions focused narrowly on CK. The student-centered conception, in contrast, is more flexible, with an understanding that learning is situational and driven less by CK and more by PCK.

The conception of knowledge advanced by Verloop et al. (2001) is reflected in recent scholarship that has focused on the inter-relationship between teacher knowledge and teacher efficacy. In their analysis of teacher knowledge related to technology education in primary schools, Rohaan et al. (2012) used a path analysis to show that CK was a prerequisite for developing PCK as well as their sense of efficacy toward using technology in instructional practices. This survey of 354 teachers in the Netherlands identified few primary school teachers who had the necessary understanding of technology to effectively integrate computers into their instruction. They further noted that more regular and meaningful PD is needed to support the greater integration of computer technology demanded by 21st century challenges.

This discussion of CK, PK, and PCK establishes the central role of teacher knowledge in training teachers to educate students for the 21st century (Fernandez, 2009; Neumann, 2016). Mishra and Koehler (2006), however, warn that the advent of digital technology has radically changed the nature of learning and teaching. Moving forward, teachers need to be equally skilled and knowledgeable about content, pedagogy, and technology. They therefore proposed an expansion of Shulman's (1986) model in the form of technological pedagogical and content knowledge (TPACK). This model distinguishes the relationships between each of the three types of knowledge: content, pedagogical, and technological. Thus, PCK is understood to be distinct from a teacher's understanding of how to use technology to deliver content, which they refer to as technological content knowledge (TCK) as well as their understanding of how to use technology to support student learning (i.e., technological pedagogical knowledge; TPK). Further, although these relationships are significant in their own right they also collectively form a more complex form of knowledge (TPACK) (Mishra & Koehler, 2006), an understanding of what is taught and how to best teach it within a specific subject matter that emerges from the interaction between content, pedagogy, and technology.

The literature surveyed above indicates that teacher knowledge is an integral component of the instructional environment. This is especially true when considering how the various forms of knowledge interact. Although CK is often a stepping stone to PCK (Grossman, 1991; Neuman, 2016), the development of PK is essential to instructional reform (Rohaan et al., 2012). Unfortunately, the accountability measures of the past few decades have served to narrow the focus for teacher education programs and teacher in-service trainings on CK at the expense of PK and PCK (DeBray, 2005; Pederson & Liu, 2003; Oancea, 2014). Without emphasis on the development of PCK, it is difficult for teachers to integrate technology to improve instruction (Mishra & Koehler, 2006) or promote SCL (Verloop et al., 2001).

Teacher beliefs and efficacy. The knowledge that teachers bring with them does not influence the instructional environment by itself. Instead, there is an inseparable relationship between teacher knowledge and beliefs, especially their sense of efficacy for teaching (Meijer et al., 2001). The link between beliefs and learning are well documented (Bandura, 1997, 2002; Ertmer, 2005; Pederson & Liu, 2003). Studies have examined the impact of teacher beliefs toward content (Powell-Moman & Brown-Schlid, 2011), new pedagogical practices and technology (Edwards & Hensien, 1999; Kopcha, 2012), and self-efficacy for teaching (Mouza, 2009; Ross & Bruce, 2007). Of these beliefs, teacher efficacy is the most stable and resistant to change (Moore-Hayes, 2011; Woolfolk Hoy & Burke-Spero, 2005).

Bandura (1977) first defined self-efficacy as a person's judgement relative to his or her ability to complete a task, served as a powerful force related to learning and motivation. Self-efficacy affects the choice of activities, the effort expended on those activities, and how long an individual will persist with those activities. A low sense of self-efficacy is related to task avoidance while a higher sense of self-efficacy equates to increased willingness to participate and overcome obstacles to complete a task (Bandura, 1977; Bandura & Adams, 1977). These factors affect both the actions of students in the classroom, leading to greater achievement, but also the role of the teacher in instruction.

To better understand the role of teacher efficacy on instruction, Hoy, Sweetland, and Smith (2000) examined the experiences of 55 novice teachers over their first year of teaching. They found that teacher efficacy was universally strong during their time preparing to enter the teaching profession but fell dramatically within months of actually becoming a teacher. This fall seemed to correlate with the decline in directed support, as novice teachers grew further removed from their teacher preparation program and received progressively less mentoring from administrators or colleagues.

A study of 350 teachers in Nova Scotia, Canada also identified how lack of support impacted teacher efficacy with digital technology. Moore-Hayes (2011) sought to understand if there was any difference in teacher efficacy between novice teachers and more established teachers when it came to the use of computer technology for instruction. Using data from a five-item questionnaire, she identified no significant differences in teacher-efficacy between novice and experienced teachers when it came to technology integration. Both groups indicated low self-efficacy when asked to integrate computers into their instructional environment with a common sense that they needed more time and support to understand the technology itself before integrating it into their lessons (Moore-Hayes, 2011). Her finding reinforces the correlation between TPACK and self-efficacy (Saudelli & Ciampa, 2014) as well as their centrality in transforming the learning environment (Skaalvik & Skaalvik, 2010).

To better understand the impact of teacher efficacy on the transformation of the learning environment, Dunn and Rakes (2010) surveyed 74 teachers pursuing a master's degree at a public mid-western university about the influence of their learner-centered beliefs on their perceptions of and self-efficacy toward technology-integration. Data were collected from all participants through the Stages of Concern Questionnaire, the Teacher Beliefs Survey learner-centered scale, and the Teacher Sense of Efficacy Survey. The results reflected a direct association between teachers' learner-centered beliefs and their sense of self-efficacy. Further, they found that both of these factors influenced teachers' perceptions of how student learning would be impacted by integrating technology in the classroom. In short, teachers who held stronger learner-centered beliefs often also had a stronger sense of self-efficacy, which in turn supported a perception that technology integration would support student learning. Thus, the authors concluded, learner-centered teachers who have a high degree of self-efficacy are more inclined to promote technology integration in their learning environment.

The results from these studies indicate that teachers' sense of self-efficacy plays a significant and enduring role in shaping the learning environment. As a critical part of teacher cognition (Borg, 2003), teachers' self-efficacy beliefs, along with their knowledge and attitudes toward transforming the instructional environment, serve to more directly and strongly influence the direction of learning than any other system of factors in the ecological model of the instructional environment.

Teacher attitudes. Although the values that teachers hold toward their students and instructional practices constitutes their beliefs, how they express those beliefs comprises their attitudes (Groff & Mouza, 2008). These attitudes form the primary second-order barrier to change in education (Borg, 2003; Ertmer, 1999; 2005). Together with the knowledge and self-efficacy that teachers bring to the instructional environment, they compose the most proximal factors influencing the instructional environment.

The attitudes teachers hold toward instruction are shaped by their role in the learning process and their past experiences (Borg, 2003). Teachers are most successful when they are active participants in learning themselves, particularly as they adopt new curriculum or technology (Borg, 2003; Marco-Bujosa, McNeill, González-Howard, & Loper, 2016). Their past experience creates context for teachers to understand what they are currently experiencing (Waitoller & Artiles, 2016) and transfer their knowledge to the instructional environment (McKenny et al., 2015; Minor, Desimone, Lee, & Hochberg, 2016). These past experiences, as well as their role as learners, shapes the attitude that they hold toward teaching, in general, and toward new pedagogical practices more specifically (Attia, 2014; Borg, 2003).

In an effort to explore the extent to which teacher attitudes were responsible for this barrier, Palak and Walls (2009) surveyed 113 teachers from 28 technology rich schools using the Inventory of Philosophies instrument. Similar to Cuban et al. (2001), by investigating only technology-rich schools, Palak and Walls removed the impact access to technology had on the instructional environment and focus on other factors that would impact how the technology was used for instruction. Their results demonstrated that the attitudes teachers hold toward technology shaped every aspect of how that technology was used in instruction. When a teacher felt that the technology was too new, too foreign, or required them to change too much of their instructional practice, they would openly avoid its use. These teachers saw technology as a threat rather than a support tool. Teachers who were exemplary technology users, however, not only used the technology more but had strong positive attitudes toward the technology.

Similar results have been observed outside the United States. Pelgrum (2001) sought to identify the attitudes of elementary and lower secondary level teachers toward the integration of Information and Communication Technologies. To address this goal, he examined the results of the Second Information Technology in Education Study (Carstons & Pelgrum, 2006), which included teachers and administrators from 26 countries. Educators reported that their top reasons for not integrating computers into their instruction included lack of resources, lack of knowledge and skills, and a perceived difficulty with regard to integrating computers in instruction. A closer scrutiny revealed teacher difficulties including a lack of vision for how computers could meaningfully aid their instruction.

These studies indicate that teachers' attitudes toward technology can have a strong influence on their decision to integrate technology into their learning environment. Zhao and Frank (2003) go so far as to equate technology as a foreign species in the classroom, invading the ecology of the instructional environment and threatening the dominant species (i.e., teachers). The evidence from studies conducted on teachers' perceptions of computers (Pelgrum, 2001), online learning (He, Xu & Kruck, 2014), blended learning (McCutcheon, Lohan, Trainer, & Martin, 2015), digital games (Hovious & Van Eck, 2015), and mobile technology (Kearney, Shuck, Burden, & Aubusson, 2012) all suggest that teachers often view technology integration with some hesitation, even hostility, which shapes their willingness to use technology in instructional practices.

Teacher beliefs and attitudes have also been shown to have a considerable impact on the integration of SCL practices. Given the differences between traditional learning and SCL, implementing any model of SCL requires teachers to make substantial changes to their instructional practices (Pederson & Lui, 2003). Khattri and Miles (1995) observed that most teachers hold traditional views regarding instruction. Those views are shared amongst teachers, creating a perception of teaching and instruction that becomes culturally embedded in the school (Tolmie, Adams, Meghani, & Smith, 2009). Such institutional perceptions are thus exceedingly difficult to challenge (Meyer & Rowan, 2006).

These barriers may, in some situations, be heightened by conflicting directives from administrative and external sources. Engle and Randall (2009) documented the impact of this conflict in an experimental design to investigate how teachers responded to students whose inquiries created a deviation from planned classroom activities. In this study, 31 teachers were asked to assist a student in an activity called Bouncing Raisins, which primarily involved conducting an experiment and recording responses on a worksheet. Teachers provided encouragement to the student either to complete the worksheet (i.e., a task-oriented directive) or to learn more about the interaction of elements. Data were collected through prestudy surveys to establish teacher perceptions toward student-centered instruction and field notes from observations of the interactions. Teachers, even those who were inclined to embrace student-centered teaching methods, would respond to a directive from a perceived authority figure with compliance rather than what they believed to be the more appropriate strategy. Grant and Hill (2006) noted a similar phenomenon in relation to standardized testing. Teachers who might otherwise have embraced student-centered teaching methods reverted to traditional teacher-directed methods if they perceived that more directed methods were better suited to student success on state tests.

The barriers to SCL practices are not only the result of perceived conflicts with policy directives. Student-centered pedagogies are also often perceived as challenging the role of the teacher in the instructional process (Kirschner et al., 2006). As Dole et al. (2016) reported in their study of problem-based learning, teachers often feel a loss of control when trying to establish SCL-based learning environments. This loss of control may also equate, in teachers' minds, to a change in their relationship with students, as reported by Brown (2012). In other words, the change from director to facilitator in the classroom is radical for teachers and may impacts the core of their professional identity (Pederson & Lui, 2003).

As the studies discussed here demonstrate, the beliefs and attitudes that teachers hold toward learning are inseparable from their knowledge and their sense of efficacy within the learning environment (Hsieh et al., 2008). In this web of instructional influences, teachers' knowledge supports their belief that they are capable instructors who can support students' learning. Likewise, teachers and students must believe that such instruction is worthwhile and that they know how to perform the tasks being set (Nuemann, 2016; Verloop et al., 2001). Such factors reside at the central microsystem of the instructional environment and most proximally influence the students who lie at the center of this model.

The Child at the Center – Student Factors

Within Bronfenbrenner's model of child development, whether nested (Bronfenbrenner, 1977) or bioecological (Bronfenbrenner & Morris, 2006), it is the child that is consistently the central focus of the model. The various layers or processes that surround the child reflect the environmental and/or psychological forces acting on the child. Similarly, in education it is the student who remains at the center of the ecological model, while the factors that impact their learning remain layered around them (Leonard, 2011). Thus, what students know and believe about technology and instruction, as well as the experiences they have with technology in an instructional setting, help define the extent to which technology can be integrated into the classroom.

Considerable evidence points to the fact that although students regularly apply the technology to address issues in their personal life, inside the classroom they often are not engaged in tasks that require application of knowledge or other forms of deep learning when using computers (Cuban et al., 2001; U.S. Department of Education, 2016). As Jang (2014) revealed, this is often explained by the expectations that teachers set within the classroom. However, Atif, Richards, Busch, and Bilgin (2015) as well as Iqball and Bahtti (2015) have pointed out that interaction with technology is heavily based on their perceptions of the new technology and the authenticity of the task they are assigned.

The value of authentic tasks within technology-based instruction formed the basis for a case study that Grant and Branch (2005) conducted in a small middle school in the Southeastern United States. They chose the particular school site for their study because it had recently adopted a schoolwide effort to implement TEL throughout the school by providing laptop computer to all students and encouraging student-centered practices. All of the participants were engaged in a project-based geography class and the teachers of those classes had agreed to shift from a teacher-centered to student-centered approach of instruction. Data were collected from five case study participants throughout a 10-week unit using interviews, classroom observations, student reflections, and artifact collection. The results from the case studies indicated that students found more value in the project-based authentic tasks than they had in previous lessons that were teacher directed. Additionally, the evidence from the classroom observations and artifacts indicated that students applied critical thinking and a rich understanding of the content to construct detailed insights into the geography related to human rights (i.e., the focus of their project) than was evident from prior unit assessments. These findings corroborate earlier studies by Cuban et al. (2001) and Pederson and Liu (2003) and demonstrate that students value learning and assessment aligned with authentic tasks that ask them to apply their learning rather than repeat information.

Students' past experiences with technology also have a direct impact on the extent to which they engage with instructional technology. Although Prensky (2006) has claimed that millennial students are digital natives who are naturally accustomed to technology use and adaptable to just about any new technology they encounter, Judson (2010) has aptly noted that the simple existence of technology in a student's life does not presuppose literacy with technology. Thomas et al. (2002) provided a clear example of this misalignment in their examination of internet integration in high schools. Although students had ready access to the internet at home, few innately understood its power as a research tool or could conduct more than a simple internet search. Students may experience heightened stress and increased negative feelings toward such technology owing to the misalignment between their personal use of the technology and the academic expectations for the same tools (Gedera, 2014).

The extent that students embrace instructional change is also dependent upon the self-perception of students toward their readiness to engage in the new learning environment. Ryan (1993) examined the concept of readiness and how it impacted student achievement amongst health science college students. Thirty-five students at the University of Western Sydney in Australia enrolled in a mandatory course that had recently been redesigned along a problem-based learning model served as participants. Data from pre and post surveys as well as grades and assessment materials indicated that students saw self-directed learning as important but also foreign. As such, they struggled to be successful without appropriate modeling. The frustration that some students felt was also compounded by what they felt was grade inflation by some instructors. Ryan concluded that implementing self-directed instruction required taking student perceptions into account and that time and guidance were needed to help students be successful in this model.

From this literature, it is clear that students themselves have an active role in facilitating technology integration in the classroom. Their understanding of how to work with computers, their past experiences with technology, as well as their perceptions of that technology and its role in education all influence the extent and purpose to which technology is used. This literature, however, also indicates that these student factors are shaped by the practices, knowledge, and attitudes that teachers bring to the instructional change process (Alexiou-Ray et al., 2003; Thomas et al., 2002). Thus, teacher factors at the microsystem level may prove to have the greatest impact on students.

Conclusion

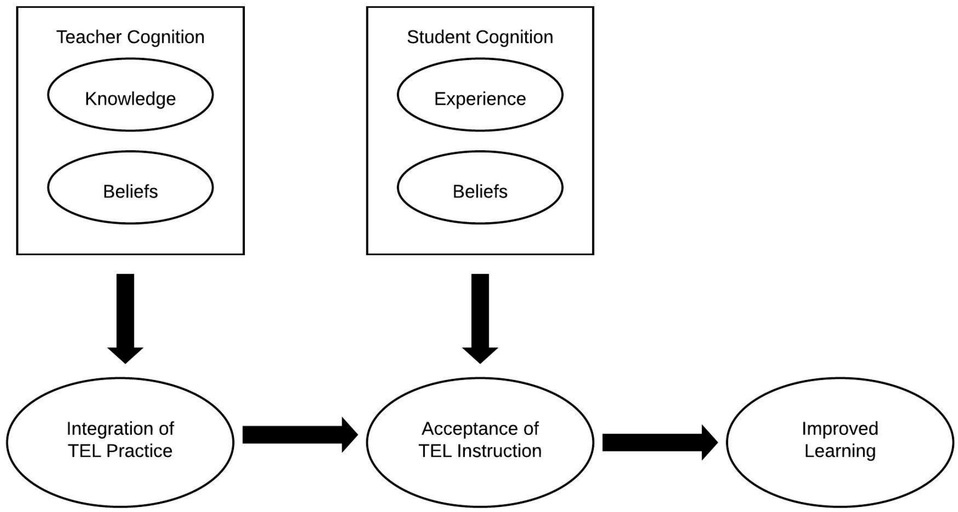
The literature reviewed in this chapter identifies the interrelated factors that make up the instructional ecology as it pertains to TEL. An examination of this ecological system reveals that although pressure to change instructional practices to address 21st-century demands are present at the macrosystem, exosystem, and mesosystem levels, the knowledge and beliefs of teachers at the microsystem level as well as those of students, at the center of the system, mediate these pressures and exacerbate barriers that protect the status quo at the instructional level.

At the level of the macrosystem, the external pressure on schools such as CMC to encourage technology integration, led by academics and policymakers often lead schools to adopt proscribed structures and norms while leaving classroom instruction and learning mostly unexamined (Diamond, 2012; Rowan, 2012). Specifically, with regard to technology integration, the findings from Cuban et al. (2001) and Capo and Orellana (2012) indicate that although schools and districts secure new computers and licenses to digital technology with the expectation that these resources will create instructional changes, teachers often use these tools as substitutes within existing practices rather than transform their practices. Supporting this continuity of their practice, as Pederson and Liu (2003) and Grant and Hill (2006) note, is the perception that such transformations are irrelevant to supporting the increased tests scores called for on accountability measures. Thus, rather than accomplish the intended instructional changes, pressures exerted at the level of the macrosystem often serve to strengthen the barriers that teachers erect at the microsystem level (Culp et al., 2003; Ingram et al., 2004; Mehta, 2014).

This resistance is further supported by the design of the school at the level of the exosystem. Small schools, such as CMC, are designed to promote a stronger sense of community, which serves to increase student and teacher work satisfaction (Carter & Keiler, 2009; Kahner et al., 2008) but often leads to a lack of urgency amongst teachers to reform instructional practices (Lehman & Berghoff, 2013; Ravitz, 2010). Evidence from Garth-McCullough (2007), for example, suggests that teachers at small schools are distanced from both district scrutiny as well as need PD insulating them from reform efforts more than their colleagues at traditional schools. Similarly, at the mesosystem level, districts are apt to ignore the lack of instructional changes when schools, such as CMC, prove to be consistently successful on accountability and other measures (Carlson & Patterson, 2015). This creates a cyclical pattern in which teachers feel validated in resisting pressure to change from more distal forces, knowing that more proximal elements will ignore them or shield them from pressure, thus reinforcing their barriers to change.

As the actions of teachers and students are most proximal to changes within the instructional environment, the most likely target for implementing the instructional changes associated with TEL at CMC are at the microsystem level (e.g., the teachers) as well as the students at the center of the system. The relationship of these changes are articulated in the conceptual framework for TEL integration identified in Figure 1.2.

Figure 1.2 Conceptual Framework for TEL Integration



As Borg (2003) and Neumann (2016) previously reported, the knowledge, beliefs, and attitudes that teachers exhibit create a web of influence surrounding their instructional practice that are critical to any instructional changes. Teacher knowledge, in this case, involves not only their understanding of their content, but also their PCK as well as their understanding of how to use technology to deliver content and facilitate new instructional practices in a manner that is unique to their area of specialization (i.e., TPACK; Shulman, 1987; Mishra & Koehler, 2006; Verloop et al., 2001). Developing this knowledge is essential to instructional reform (Mishra & Koehler, 2006; Rohaan et al., 2012). Equally important, however, in light of the close relationship between teacher knowledge and beliefs (Meijer et al., 2001) is the need to support teachers in developing constructive beliefs and attitudes toward TEL. The beliefs and attitudes that teacher hold toward technology shape how they use that technology within their instructional environment (Pallak & Walls, 2009), resulting in a lack of integration or limited pedagogical changes when teachers hold negative views of technology or if they lack a sense of efficacy toward its use (Dunn & Rakes, 2010; Moore-Hayes; 2011). Similarly, teachers who feel a lack of confidence in creating SCL tasks for their students or who perceive such practices as challenging their role as a teacher are unlikely to implement the instructional changes needed to create TEL (Dole et al., 2016; Kirschner et al., 2006).

At the same time, the beliefs and experiences that students bring to the learning environment help to shape their participation with technology in an instructional setting and their willingness to embrace change within that setting. Their past experience with technology, both outside the classroom as well as in previous classes, may support their learning within TEL if they have grown comfortable with the technology to be adaptable. It may also lead to increased distress or negative feelings toward technology if there is a misalignment with their understanding of the technology and the academic expectations placed on the use of these tools (Judson, 2010; Gedera, 2014; Thomas et al., 2002). In a similar manner, their ability to embrace instructional change, such as SCL practices, is dependent on their readiness to participate in a transformed learning environment. A misalignment of their readiness to engage in SCL tasks and the academic expectations placed on them through such tasks can impact both their perceptions of such tasks as well as their overall learning within a class (Iqball & Bahtti, 2015; Perderson & Liu, 2003; Ryan, 1993).

Based on these findings and the need to understand the system that has produced the problem as it exists at CMC in accord with the science of improvement (Bryk et al. 2015), a needs assessment study was conducted to investigate the factors related to TEL integration at the teacher (i.e., microsystem) and student (i.e., system center) levels at CMC. The context and findings of that study are reported in Chapter Two.

Chapter Two

Empirical Examination of Factors and Underlying Causes

The global economic, social, and technological realities of the 21st century require that students engage in learning that builds skills related to problem solving, collaboration, effective presentation of their ideas, and the ability to use technology in a flexible and sophisticated manner (Alexiou-Ray et al., 2003; Bybee & Starkweather, 2006; Culp et al., 2003; Lee & Hannifin, 2016). Furthermore, research from a learning sciences perspective supports the formation of collaborative, inquiry-based, and authentic learning environments (Bandura, 2002; Bransford et al., 2000; Gee, 2008; Gedera, 2014). Such changes, however, represent a radical departure from traditional learning and may create barriers to change on the part of teachers and students (Abbot, 2005; Becker, 1994). Investigating the nature of these barriers requires focusing on factors that are most proximal to the instructional core of learning (e.g., the teachers and students in the classroom). These factors include teacher knowledge and skills (Grossman, 1991; Henderson, 1988; Neuman, 2016); teacher efficacy (Rohaan et al., 2012; Verloop et al, 2001); and teacher beliefs and attitudes toward instruction and the instructional environment (Khattri and Miles, 1995; Palak and Walls, 2009; Pederson & Lui, 2003).

Context of Study

I conducted this study at CMC, a comprehensive alternative public high school with a population of approximately 400 students. Following the middle college model, CMC is located on a community college campus and all students are concurrently enrolled in community college classes as part of their high school program. Evidence from the school's 2015 accreditation indicated that CMC is a high performing secondary school, ranking in the top 5% of all schools in California. Carlson and Patterson (2015) noted that such schools tend to see their past performance as affirming the validity of their existing practices, which may limit motivation to change. Some of the teachers at CMC expressed similar perceptions in the years prior to this study. A review of the school's 2015 accreditation report identified how the recent adoption of the Common Core State Standards and Next Generation Science Standards, however, has caused some teachers at the school to accept, if not embrace, the need for changes to the instructional environment. Such sentiments are consistent with DeBray (2005) and Donnely and Sadler (2009) who reported that teachers respond to external accountability reforms with compliance.

CMC is also what Cuban et al. (2001) refer to as a "high access" school in relation to technology. Recent findings from the accreditation report as well as a district-wide technology survey (BrightBytes, 2016) indicate that students and teachers both own and regularly use computers outside of school. Within the school, there is a teacher computer in every class and six laptop carts totaling 187 operational laptop computers that students can access during class time. The apparent ease of access to computers within the school is complicated, however, by housing some of these carts in teachers' individual classrooms. This leads to a sense of ownership among those teachers, as well as increased competition for the remaining laptop carts. This attitude is consistent with the behavior reported by Cuban et al. (2001) as is the prominent use of computers at CMC for directed instructional activities such as lecturing, word processing, and occasional internet research for a paper or project.

This focus on direct instruction is supported by the design of the classrooms and school environment at CMC. Classrooms are all designed with rows of free-standing chairs that have narrow desk surfaces facing a whiteboard and the teacher's desk located to the front and far left from the students' perspective. Each room has one door leading from a common hallway, which students are expected to enter and a door to the outside of the school through which students are expected to exit. The hallways are narrow and easily congested. According to Brown (2011), collaboration, personalization, and student autonomy within instruction, all hallmark traits of SCL, are significantly impacted by such restriction of space and naturally rigid expectations for student behavior within that space. This design limits the development of the skills and competencies that students need to be successful in the 21st-century (Dimmock, 2002).

Demographic school data obtained from a school enrollment report in April 2016, right before the needs assessment study was conducted, indicated that 61% of the population was female and the majority of students identified either as Asian or White (see Table 2.1). The 2015 accreditation report noted that about 4% of the population had a primary language other than English, with Spanish and Korean being the prominent native languages. Approximately 8% of the population was classified as living in a lower socio-economic household. The report further identified that these numbers reflected the population of the school district as a whole.

Table 2.1
Ethnicity of School Population, By Grade Level

	9th Grade (n=84) n (%)	10th Grade (n=94) n (%)	11th Grade (n=109) n (%)	12th Grade (n=97) n (%)	Combined (n=384) n (%)
Hispanic	13 (15.4)	20 (21.2)	30 (27.5)	13 (13.4)	76 (19.7)
Asian	20 (23.8)	27 (28.7)	34 (31.1)	31 (31.9)	112 (29.1)
Black or African American	3 (3.5)	2 (2.1)	4 (3.6)	5 (5.1)	14 (3.6)
White	46 (54.7)	38 (40.4)	36 (33)	47 (48.4)	167 (43.4)
2 or More Races	2 (2.3)	7 (7.4)	5 (4.5)	1 (1)	15 (3.9)
Total	84 (100)	94 (100)	109 (100)	97 (100)	384 (100)

In the 2015-2016 school year, there were 12 teachers, including two mathematics teachers, two science teachers, four English teachers, and four social studies teachers. The school's accreditation report noted that eleven of the teachers identified as White, while one teacher identified as Latino or Hispanic. There were an equal number of male and female teachers. All but one of the teachers had more than five years of teaching experience, with most having taught for more than ten years. Except for the two mathematics teachers, all teachers taught within grade-specific cohorts.

Purpose of Study

The purpose of this needs assessment study was to investigate the extent to which instructional practices at CMC aligned with student-centered practices, the extent to which computer technology was being used to facilitate these practices, and the perceptions of students and teachers toward TEL.

The following questions were used to guide this investigation:

1) To what extent do teachers and students at CMC report the use of a TEL environment in their classes?
2) To what extent do classroom observations at CMC corroborate students' and teachers' perceptions of the existence of a TEL environment?
3) To what extent do teachers at CMC report facility with and knowledge of TEL environments?
4) What are teachers' self-reported beliefs and attitudes regarding TEL environments at CMC?

Method

For this needs assessment study, I used a convergent (also referred to as concurrent or parallel) mixed-methods design. This method involves the simultaneous collection of qualitative and quantitative data, analyzing the data separately, comparing the results from both types of data, and interpreting the extent to which the results converge or diverge from one another (Creswell, 2015). Such methods support triangulation of the findings and allow for the relative strengths of each type of data to offset any weaknesses in the other type of data (Johnson & Onwuegbuzie, 2004). In the next section I detail how participants were selected, the measures used in the study, and the procedure that I followed, including the methods used for collecting and analyzing data from the measures.

Participants

I collected data from the students and teachers at CMC.

Student participants. Three hundred eighty-seven students were enrolled in the school at the time of the data collection. Two hundred eighty-eight students returned signed consent forms to participate in the study, and 284 participated in the survey (response rate = 73.38%). The majority of participants were female and students who identified as being White or Asian. These statistics closely align with the demographic data, presented above, for the entire school. The complete breakdown of the student participants by ethnicity and gender is provided in Table 2.2.

Table 2.2
Ethnicity of School and Sample Student Populations

	School (n=384) n (%)	Sample (n=284) n (%)
Hispanic	76 (19.7)	53 (18.6)
Asian	112 (29.1)	85 (29.9)
Black or African American	14 (3.6)	11 (3.8)
White	167 (43.4)	123 (43.3)
2 or More Races	15 (3.9)	12 (4.2)
Total	384 (100)	284 (100)

Teacher participants. Eleven of the 12 of the teachers at the school participated in the study, including six females and five males. The teachers represented the four academic disciplines taught at CMC, with four English teachers, three social studies teachers, and two teachers each from mathematics and science. Six of the teachers were selected to be interviewed and observed. These six teachers were selected with representation from all four departments and all grade levels. Table 2.3 provides demographic data for these teachers with the pseudonyms assigned to each for the purpose of this study.

Table 2.3
Characteristics of Case Study Population

Teacher (Pseudonym)	Department	Years of Experience
Andy	Mathematics	Less than 5 Years
Gloria	English	More than 20 Years
Madison	Social Studies	15-20 Years
Richard	Social Studies	5-10 Years
Ryan	English	10-15 Years
Vanessa	Science	15-20 Years

Measures

Data for this study came from multiple quantitative and qualitative measures. I used secondary data from a district-commissioned survey of technology as well as data from surveys designed and administered for this study to address the first research question and to provide context for the remaining questions. I also used classroom observations, teacher interviews, and short-answer questions from the surveys designed for this study to investigate the nature of classroom interactions as well as teacher knowledge, beliefs, and attitudes toward TEL. Table 2.4 identifies each measure, the data collection mechanism, and the variable.

Table 2.4
Needs Assessment Matrix

Construct	Data Source	Items in Data Source
RQ 1. To what extent do teachers and students at CMC perceive the existence of a TEL environment in their classes?		
Perceptions of TEL Environment	CST Survey (see Appendix A)	13, 14, 15, 16, 18, 20, 39, 40, 41, 42, 43, 44, 45, 53
	STPLE Survey (see Appendix B)	4, 5, 8, 12, 13, 23, 24, 25
	SSPLE Survey (see Appendix C)	8, 9, 10, 11, 12, 13, 14, 16, 17, 18, 19, 20, 21, 22, 25, 26, 27, 28, 29, 30, 31, 34, 35, 36, 37, 38, 39, 40
RQ 2. To what extent does observational data from classrooms at CMC corroborate students' and teachers' perceptions of the existence of a TEL environment in their classes?		
Perceptions of TEL Environment	Classroom Observations (See Appendix D)	
RQ 3. To what extent do teachers at CMC report facility with and knowledge of TEL environments?		
Teacher Knowledge of TEL	CST Survey (see Appendix A)	36, 37, 38, 48
	STPLE Survey (see Appendix B)	14, 16, 18, 28, 30, 31, 32
	Teacher Interviews (see Appendix E)	
RQ 4. What are teachers' self-reported beliefs and attitudes regarding TEL environments at CMC?		
Teacher Beliefs and Attitudes Toward TEL	CST Survey (see Appendix A)	34, 35, 55, 56
	STPLE Survey (see Appendix B)	6, 9, 10, 11, 15, 17, 22, 27
	Teacher Interviews (see Appendix E)	

Clarity Survey of Technology Use by Students and Teachers. I collected secondary data from the Clarity Survey of Technology Use by Students and Teachers (CST; see Appendix A) to assess the extent that students and teachers perceived the existence of TEL in their classes. The student survey included 16 multiple choice questions and 56 Likert scale questions while the teacher survey included 40 multiple choice questions and 100 Likert scale questions. In both versions, the multiple-choice questions addressed demographics information as well as the type of technology that students and teachers had access to and used at home and at school. For example, one question asked if participants owned a desktop computer while another question asked participants to identify from a list the major obstacles they encountered in using technology at school. The Likert scale questions asked all participants about the amount of time they used specific forms of technology at home and at school, how easy they found it to use specific types of technology, and the extent to which they agreed with statements about the use of technology within the classroom. For instance, one question asked participants the extent to which they agreed that learning was more engaging when technology was included in a lesson. Scales on the teacher survey also asked questions about teacher efficacy using technology, how often they used technology as part of their instruction, and how much time they spent instructing students on appropriate use of technology. For example, one prompt asked teachers how easy they found it to collaborate with others using online tools. Other examples from each survey are listed in Table 2.5 and the full instrument is located in Appendix A.

Table 2.5
Examples of CST Likert Scale Items

Prompt Stem	Scale	Item #s	Example
Student Survey			
How easy is it for you to do the following?	Very easy, easy, moderate, hard, I don't know how to do this	13-23	Send emails
How often do you do the following?	Almost daily, weekly, monthly, every few months, never	24-41, 43-67	Read things on the internet, such as blogs and news sites
How strongly do you agree with the following statement?	Strongly agree, agree, neutral, disagree, strongly disagree	70-74	Technology in the classroom enhances my learning
Teacher Survey			
Indicate how strongly you agree or disagree with the following statements	Strongly agree, agree, neutral, disagree, strongly disagree	38-41	I easily find new technologies to meet my teaching goals
How often do you ask a majority of your students to do the following?	At least weekly, monthly, every few months, never	67-89	Conduct research online
How much time do you spend each year formally or informally teaching students about the following topics?	More than 5 hours, 3-5 hours, 1-3 hours, less than an hour, I don't teach this	90-94	Being safe online

Survey of Teacher Perceptions of the Learning Environment. To further investigate the extent to which teachers perceive TEL as existing in their classes as well as to measure their beliefs and attitudes toward TEL, I developed a Survey of Teacher Perceptions of the Learning Environment (STPLE; see Appendix B) by adapting An and Reigeluth's (2011) study of TEL classrooms in Arkansas. This survey was independently reviewed by two experts to establish face validity. I calculated Cronbach's Alpha at 0.554 for the survey as a whole and between

0.254 and 0.396 for each subscale. As these scores indicate a low reliability for the instrument, the responses were used solely for descriptive purposes.

The instrument included two multiple-choice demographic questions concerning teaching assignment and years of experience, four open-ended questions, and 26 five-point Likert scale items. The response choices for the Likert scale items was 1 for strongly disagree and 5 for strongly agree. The scaled questions were grouped to address seven constructs including teacher perceptions toward SCL, barriers to implementing SCL, and perceptions of the opportunities they created for student collaboration, metacognitive activities, and creative thinking in the classroom. For example, responses to prompts such as “student-centered approaches increase the amount of content I can teach” address the beliefs and attitudes that teacher hold toward SCL. The open-ended questions sought to probe teachers’ understanding more deeply with questions such as “how would you define student-centered learning?”

Survey of Student Perceptions of the Learning Environment. I adapted a separate survey, the Survey of Student Perceptions of the Learning Environment (SSPLE; see Appendix C), from the Colorado Student Perception Survey-Grades 6-12 (Colorado Education Initiative, 2014). The instrument was independently reviewed by two experts, and I calculated Cronbach’s Alpha at 0.788 for the instrument as a whole and between 0.688 to 0.725 for each subscale. The instrument included one demographic question and six 5-point Likert items with 1 indicated strongly disagree and 5 indicated strongly agree, repeated for each of the four disciplines in which students were enrolled (i.e., English, mathematics, science, and social studies). For example, students were asked to indicate the degree to which they agreed with the statement “the lessons in this class are clearly relevant to the world we live in today and are preparing me for success in the world past high school” for each of the content areas. As not all students are enrolled in mathematics and science classes at the high school level (upper-classmen tend to take these courses at the college level), participants responded to between 12 and 24 statements.

Classroom observations. Observations were non-participatory, with field notes recorded during each session using protocols established for this needs assessment study (see Appendix D). Following guidelines suggested by Creswell (2015), the protocols included a header, a space to record descriptions of the observed teacher actions and expressions, another space to record observed student actions and expressions, and a separate space for recording reflective notes.

Case study interviews. I conducted semi-structured interviews with case study participants using questions developed for this study (see Appendix E). In these interviews, teachers were asked to describe their teaching style, how they integrated technology into their lessons, the role of collaboration and project-based activities in their lessons, and their definition of SCL.

Procedure

In line with the convergent mixed-methods design guiding this study, I collected both quantitative and qualitative simultaneously. I then analyzed descriptive statistics from the quantitative sources, while I coded the qualitative data using a priori codes while looking for emergent themes.

Data Collection. I administered the CST to all students and staff at the start of the spring semester in 2016. I administered the STPLE and SSPLE surveys separately toward the middle and end of the spring 2016 semester at the same time that the teacher interviews and classroom observations were conducted.

CST survey. BrightBytes Inc. administered the CST survey online to all teachers, students, and parents of students at CMC in January 2016. They provided a two-week window for participants to complete the survey. They made the results from that survey available in aggregate form to school administrators at the beginning of April 2016.

STPLE survey. I administered the STPLE online through surveymonkey.com with specific user names and passwords to ensure data security. All participants completed the survey within 15 minutes during a designated staff meeting.

SSPLE survey. I administered the student survey in separate sessions over the course of three days. A laptop cart with 34 laptops was secured to ensure all students had access to the online survey during a designated period. As almost all CMC students are enrolled in a specialized elective course called Advisement, the survey was administered in each of these classes. I created a separate password for each advisement class and the collection window for each class was only open for the 15 to 30 minutes required for students to complete the survey in that class.

Classroom observations. I conducted four observations in the six case study teachers' classrooms over the course of three months. I recorded field notes and detailed summaries of each observation using a Livescribe pen. I also developed a narrative reflection immediately after each observation.

Teacher interviews. I conducted semi-structured interviews at the conclusion of the classroom observations (see Appendix E). I asked teachers to describe their teaching style, their perception of SCL, the role of collaboration and project-based activities in their lessons, and how they integrated technology in instruction. The interviews lasted approximately 30 minutes each. All interviews were recorded and transcripts were produced following the interviews.

Data Analysis

In accordance with the convergent mixed methods approach, I first analyzed the quantitative and qualitative data separately then combined them for deeper analysis.

Quantitative data. I calculated descriptive statistics for the quantitative data including frequencies, means, and standard deviations. Owing to the small teacher sample size, I reported STPLE results as frequency tables only and the scales were collapsed so that responses that indicated Strongly Agree and Agree or Strongly Disagree and Disagree were merged. I reverse-coded two negatively-worded statements in the SSPLE and four such statements in the STPLE prior to analysis. I analyzed responses from the SSPLE using the SPSS software package (version 24). I determined that one item from each scale of the SSPLE, related to the extent to which a class was boring, was unrelated to the research questions and did not included it in the analysis.

I calculated the mean and standard deviation for each item in the SSPLE by department, grade level, and across disciplines for the survey as a whole. For example, the item "the teacher is the focus of this class," was addressed by each 9th grade student four times, once each for his or her English, mathematics, science, and social studies classes. As such, these responses were included in the average score reflecting students' perceived instruction in English across grade levels, in instruction in the 9th grade across departments, and as a combined measure of all responses across grade levels and disciplines. This allowed for a general understanding of student perceptions at the department, grade, and school levels.

Qualitative data. I transcribed all sources of qualitative data and entered them into Dedoose, an online software system used for coding. These data included notes from the interviews, classroom observation field notes, responses to the four open-ended questions from the STPLE survey, and interview transcripts. I read and coded individual sources in an iterative process to investigate emergent themes. I established codes reflecting elements of SCL as well as teacher knowledge, use of, and perceptions toward technology in instruction from these general notes. I then re-read the data to identify additional evidence of those codes and to identify patterns within the codes. Finally, I reduced these codes to four themes and the sources were read a final time for these themes.

Findings

The data describe a complex picture related to technology integration and student-centered practices at CMC. Although many teachers and students believe that their classes were already using technology regularly and creating SCL opportunities, classroom observations and teacher interviews demonstrated little evidence of either meaningful technology integration or regular student-centered practices. Teachers consistently demonstrated enthusiasm for such changes but also willingly acknowledged their limited understanding of SCL practices, uncertainty with their skills and knowledge regarding technology integration, and exhibited concerns about how these changes impact their role as teachers. The following discussion addresses these results as they relate to individual research questions.

Teacher and Student Perceptions of the Existence of TEL (RQ1)

I analyzed data from the CST, STPLE, and SSPLE surveys to understand the extent to which teachers and students perceive the existence of TEL in their current classrooms. In general, teachers and students perceived that some SCL practices were being integrated into classroom instruction including collaboration-based projects and regular computer use in most classrooms. At the same time, both groups identified limited use of technology within practices that are critical to SCL instruction, especially the use of authentic tasks.

SCL practices. Due to the small sample size, I only report frequency data from the teacher survey. As the results from the Perceptions of SCL subscale on the STPLE (Appendix F) demonstrate, the teachers at CMC viewed some SCL practices as already present in their classes. Notable is the fact that 100% of the teachers indicated that their activities are specifically designed to stimulate higher-order thinking. Equally insightful is that all but one teacher (90.9%) reported that their lessons currently promote other major tenants of SCL including student self-assessment, collaboration, and relevance to contemporary issues or events. Teachers diverged from this pattern only once, when responding to a reverse-worded statement about lessons being constructed with a specific answer in mind. Only three of the 11 teachers disagreed with this statement aligned to a directed-learning paradigm. This inconsistency is potentially reflected in the low reliability estimates for this scale.

In contrast, results from the directed learning subscale of the student survey (see Appendix G) indicated that students perceived a greater incidence of practices consistent with directed learning (M = 3.59, SD = 0.68). This was most prominent with regard to instruction in mathematics (M = 4.31, SD = 0.76). More generally, students indicated that the teacher was most often the focus of learning (M = 3.87, SD = 0.73) with a slight emphasis on lecture-based activities (M = 3.31, SD = 0.85). At the same time, students also reported instructional activities that provide them opportunity for reflection (M = 3.9, SD = 0.73), student collaboration (M = 4.23, SD = 0.58), and authentic learning activities (M = 3.95, SD = 0.62). This suggests that elements of SCL are being integrated in CMC classes but not consistently or in a manner that gives students a sense of agency within instruction.

Technology integration. Results of the CST survey (Appendix H) indicate that both teachers and students identified a high level of general technology use in classes on a weekly basis (92% and 82%, respectively). Students, however, indicated higher weekly rate of technology use for collaboration (73% compared to 15% by teachers), sharing documents (85% compared to 38%), collecting and analyzing data (50% as opposed to 25%), conducting research (80% in relation to 58%), and creating multimedia presentations (84% versus 50%). In contrast, both students and teachers indicated minimal use (i.e., either every few months or never) of technology to engage in writing for a public audience (i.e., blog posts or posting commentary online), receiving feedback from other students, or for creating and uploading art, movies, music, or webcasts.

In general, the data from these surveys indicate that both teachers and students report that elements of TEL are already present in their classes for research, data collection, collaboration through digital documents and creation of digital presentations. The use of technology for collaboration and the creation of multimedia projects satisfies some aspects of TEL. Both teachers and students, however, also identified tasks that are more authentic in nature (e.g., writing for an online platform or the creation of art, music, movie, and webcasts) as occurring only occasionally or never. Such tasks are an essential feature in the long-term transformation of the instructional environment toward TEL (Ke & Kwak, 2013).

Observed Evidence of TEL (RQ2)

I conducted a series of four observations in the six case study teachers' classrooms to examine the extent to which practices consistent with TEL were integrated into current CMC classes. Table 2.6 identifies the frequency of observed instructional practices that were noted in those observations, including multiple instances within the same lesson. These include teacher activities that are consistent with directed instructional practices (i.e., lecturing, demonstrating how to solve problems, etc.), student activities such as essay writing or completing online forms that are also consistent with directed instruction, as well as SCL practices that included collaboration, use of authentic tasks, and student reflection.

Table 2.6
Frequency of Observed Teacher-Directed or SCL Practices

	Teacher-Directed Practices		
Teacher	Teacher Activities	Student Activities	SCL Practices
Gloria	4	1	0
Richard	3	4	0
Madison	4	6	6
Andy	3	4	2
Vanessa	2	5	1
Ryan	1	3	10
Total	17	23	19

It is notable that although I observed multiple uses of technology in each teacher's class at some point in the observation process, these were often limited to teacher-directed practices. In most cases, teachers used the technology to present lectures or students engaged technology to look up basic information, conduct calculations, or complete a brief directed task such as completing a worksheet. I observed few instances of problem solving, project design, or collaboration. In one example, Richard had students engaged in a simulation involving the signs of genocide that arose from examining the Holocaust and how such signs could be applied to the Syrian refugee crisis. Although the activity was relevant to our contemporary world and engaging for most students, it was carefully scripted and very limited to recognizing specific signs of genocide. It did not require any problem solving or application of knowledge. Similarly, Andy had students engaged in technology-based tasks that allowed for personalization (i.e., choosing their own topic or design), but the task was limited in scope and duration and was directed by a prompt that allowed for no variation in how the participants engaged with the task.

Such constraints prohibit the deeper exploration and application of knowledge that is central to SCL practices (Daigle, 2000; Hmelo et al., 1997; Pederson & Lui, 2003).

Only Ryan's class demonstrated a consistent, regular application of technology in a student-centered process. An example is the multicultural project that his students were working on during two of the classroom observations. Students were tasked with identifying a culture with which they identified closely (i.e., personalization), conducting detailed online research on that culture to determine a central argument about the culture and its role in the broader American society today (i.e., critical thinking), and then creating a multimedia presentation (i.e., authentic learning). A built-in reflection process further supported metacognitive reflection. In this way, this project included all of the major elements of TEL except collaboration.

Although some of the observed teachers demonstrated elements of SCL within their classroom instruction to varied degrees, all of them demonstrated a prominent use of directed instruction within their lessons. Lectures were the most common feature and were evident in all but two of the observations. Three teachers in particular, Gloria, Richard, and Madison, seemed to consistently rely on lectures, with students answering questions posed by the teacher as the primary form of student engagement. Other directed instructional tasks included filling out worksheets, using calculators or digital mathematics programs to help solve mathematics equations, word processing to write essays, and completing tasks that were part of an interactive slideshow presentation.

Some tasks appeared designed to be student-centered in nature, but the application of the lesson turned it into a directed assignment. For example, Vanessa's class engaged in an online laboratory experiment that was meant to help students understand stoichiometry. Although there was considerable potential for student-centered activity in this lesson, the end product was a worksheet that students filled out by themselves, which shifted this assignment toward directed instruction. Similarly, Madison's class engaged in a project in which they had to design a marketing campaign to support or reject raising the federal minimum wage. The student-centered nature of this activity, however, was undermined by rigid guidelines and inconsistent directions. In the end, the groups produced almost identical products toward which they seemed unenthusiastic.

The observations suggest that TEL practices were not as evident as students and teachers believe. Teachers primarily used technology to facilitate lectures or to engage students in research on isolated objectives (i.e., looking up the answers to a worksheet) much the same as they traditionally would with a textbook. Students used technology primarily for research and writing; however, there is evidence of digital collaboration that seems well integrated into both the research and production phases for various projects. Multimedia presentations were also on display during these observations, which indicate a more sophisticated use of technology for slideshows and oral presentations but not for the production of videos, animations, or other forms of stand-alone presentations. Such presentations represent a more sophisticated application of knowledge and skill (Thomas et al., 2002) that is expected from authentic integration of TEL (Hannafin & Land, 1997).

Teacher Facility with and Knowledge of TEL (RQ3)

I examined the results of the CST survey, the open-ended responses from the STPLE survey, and the notes from the interviews with case study participants to investigate the extent to which teachers have knowledge and facility toward TEL, the focus of the third research question. Teachers at CMC generally felt confident that they could use technology effectively within their classes (see Table 2.7). Only one teacher expressed some hesitation toward the use of technology in the classroom. The remaining teachers reported being confident that they can find digital technology to incorporate into lessons and in their ability to manage a classroom where students are using technology. At the same time, teachers presented a mixed perception of their knowledge related to using technologies, with at least half of the teachers unsure of their knowledge in creating an online presence or using digital content legally.

Table 2.7
Frequency of Teacher Reported Facility with and Knowledge of Technology Use (n=12)

Prompt	Strongly Disagree/ Disagree *n* (%)	Neutral *n* (%)	Strongly Agree/ Agree *n* (%)
I Feel Confident Managing a Classroom Where Students are Using Technology	1 (8)	0 (0)	11 (92)
I Easily Find New Technologies to Meet my Teaching Goals	1 (8)	0 (0)	11 (92)
I feel knowledgeable when it comes to:			
Creating an online presence	1 (8)	5 (42)	6 (50)
Legally using digital content	2 (16)	8 (64)	2 (16)
Being safe online	1 (8)	0 (0)	11 (92)

The responses from the STPLE further indicated more uncertainty toward tasks that are not teacher directed (Table 2.8). All but one teacher (90.9%) reported that they already engaged students in authentic problem-solving activities (a core component of SCL practices), but 63.63% were also neutral or disagreed that a student-centered approach could increase the amount of content they could teach. Meanwhile only 63.63% reported any confidence in their ability to design lessons that are personalized to individual students. Most teachers (81.81%), however, were confident that students are ready to take greater responsibility for the learning process. Most significantly, the majority of teachers (72.72%) wanted to know more about how to incorporate SCL practices into their instruction.

Table 2.8

Frequency of Teacher Reporting of Facility with and Knowledge of SCL (n = 11)

Prompt	Strongly Disagree/ Disagree *n* (%)	Neutral *n* (%)	Strongly Agree/ Agree *n* (%)
A student-centered approach does not require a lot of work and is realistic for most of my lessons. (reverse coded)	3 (27.27)	1 (9.1)	7 (63.63)
I want to learn more about student-centered instruction.	0 (0)	3 (27.27)	8 (72.72)
I am ready to create lessons that ask students to solve problems that are meaningful to larger issues or concerns in the world today.	0 (0)	1 (9.1)	10 (90.9)
Student-centered approaches increase the amount of content I can teach.	5 (45.45)	2 (18.18)	4 (36.36)
I am ready to create lessons that ask students to solve problems that are meaningful and relevant to them individually.	0 (0)	4 (36.36)	7 (63.63)
I am very familiar with student-centered approaches.	0 (0)	7 (63.63)	4 (36.36)
My students are ready for tasks in which they have to take responsibility for their learning.	2 (18.18)	0 (0)	9 (81.81)

As part of the STPLE survey, teachers were asked to define SCL. Their responses to that prompt demonstrate an incomplete understanding of the concept. Teachers most commonly associated SCL with matching lessons to the needs and abilities of students (27%), engaging students through prior knowledge (27%), and shifting the focus of learning from the teacher to the student (27%). About half, however, were able to identify pedagogical strategies that often support SCL practices (e.g., small and large group discussions, problem-based activities, and the creation of joint projects). This disconnect suggested that their understanding of SCL was incomplete or that the term was novel and understood in a literal sense (i.e., any interaction with students).

Within the interviews with case study participants, a few teachers also noted a need to understand more about technology and its uses. Ryan and Vanessa, for example, both indicated that they wished they understood technology better. Madison not only indicated that she needed a better understanding about technology but stated that “sometimes I think that they (students) are looking for ways to make me not look like I know what I am doing (with technology).” This statement indicates that Madison sees her existing knowledge-base as a significant problem; one that threatens her identity as a teacher.

As evidenced in these survey responses and interviews, although teachers generally reported confidence that they could use technology effectively, they were not confident in their ability to design lessons that use technology for SCL purposes. They were also uncomfortable with the amount of work it takes to facilitate TEL and felt that using such pedagogical practices would reduce the amount of content they are able to cover. These are common concerns related to the integration of SCL (Dole et al., 2016). The teachers also demonstrated an incomplete understanding of TEL and the practices generally associated with SCL. This is also not uncommon with regard to SCL practices such as inquiry-based learning as Hmleo-Silver et al. (2006) have reported.

Teacher Beliefs and Attitudes about TEL (RQ4)

I also examined the results from the CST survey, open-ended questions on the STPLE survey, and teacher interviews to investigate the beliefs and attitudes that teachers hold toward TEL. In general, teachers overwhelmingly expressed value in incorporating technology within their classroom instruction. All of the teachers responded positively to every statement concerning the inclusion of technology in the classroom (see Table 2.8). Strong agreement with statements such as “technology use in class can enhance student learning” and “technology use in class enhances student engagement” suggests that the teachers at CMC see value in using technology in their classes to support student learning. Such statements, however, are not necessarily indicative of regular use of technology (Moore-Hayes, 2011) or use of technology for SCL-based activities (An & Reigeluth, 2011).

Teacher responses on the STPLE demonstrated that their beliefs about SCL are complex. As shown in Table 2.9, teachers strongly agreed with statements related to increasing student responsibility in learning (100%), having students assess their individual learning (90.9%), and compatibility between SCL strategies and their subject (90.9%) and the school’s bell schedule (81.81%). They were more divided on the need to establish a quiet classroom (an indicator of direct-learning), the need for students to try new approaches even if they lead to failure, as well as the role of students in determining the form of their learning and assessments. In contrast to previous statements that broadly supported SCL approaches, teachers also strongly agreed with the statements that students should “take direction and work at the pace I (the teacher) set” (81.81%) and “some lessons are important, even if students don’t find them meaningful” (100%). Such statements are more strongly aligned with directed-learning approaches (An & Reigeluth, 2011).

Table 2.9

Frequency of Teacher Reported Beliefs and Attitudes Toward SCL (n = 11)

Prompt	Strongly Disagree/ Disagree *n* (%)	Neutral *n* (%)	Strongly Agree/ Agree *n* (%)
It is important to give students increasing responsibility for the learning process.	0 (0)	0 (0)	11 (100)
It is important that students engage in activities which require them to assess their individual learning and areas of growth.	0 (0)	1 (9.1)	10 (90.9)
Student-centered approaches are compatible with my subject area. (Reverse coded)	0 (0)	1 (9.1)	10 (90.9)
Student-centered approaches are compatible with our bell schedule. (Reverse coded)	1 (9.1)	1 (9.1)	9 (81.81)
A noisy and active classroom, in which students do more than respond to review questions when prompted, is evidence that students are engaged in learning. (Reverse coded)	2 (18.18)	2 (18.18)	7 (63.63)
Students should be encouraged to try new approaches to problems or activities, and even fail without repercussions.	0 (0)	4 (36.36)	7 (63.63)
Students should be included in decisions about how and what they learn and how that learning is assessed.	1 (9.1)	5 (45.45)	5 (45.45)
It is important that students are self-directed and work at their own pace. (Reverse coded)	9 (81.81)	1 (9.1)	1 (9.1)
The only time a lesson is important is if students find it meaningful. (Reverse coded)	11 (100)	0 (0)	0 (0)

Teacher interviews also indicated that they see TEL as a complex process that is not always applicable to their classroom. All of the teachers interviewed indicated that integrating technology within the classroom is important. Three teachers, however, also expressed concern about this integration and how it impacted both their role as a teacher and the sense of equity within the school. Madison, as was previously noted, expressed concerns during her interview about her technological knowledge base as well as a concern that her students understood how to use technology better than she did. Similarly, Vanessa reported that having her students work independent on an online laboratory simulation made her uncomfortable. "I feel useless as a teacher. For 17 years I'm there, I'm helping them, answering questions. But when they're interacting with technology, I'm not in the equation at all, so I don't know how to assess their understanding of it." For both of these teachers, TEL practices represented a change in their role as a teacher, potentially threatening their sense of identity.

In addition to their thoughts about technology use, interviews with the case study participants revealed nuanced perceptions about SCL practice. Gloria, for example, talked at length about the importance of the projects in which her students engaged during the year, including an interactive unit on Shakespeare's Romeo and Juliet. To her, these units help students be engaged in learning and see how learning applies outside of the classroom. Andy expressed a similar belief when he said "that's where I would say they're going to engage in my class, because if I do a project-based lesson, that's one where they're going to engage" as he detailed a housing project that his algebra students completed. Along with Ryan and Richard, these teachers believed that these projects helped make authentic connections between the classroom and real-world contexts.

All of the case study participants also mentioned collaboration as having some role in their instructional practices, though not always a large role. Although Madison and Ryan indicated that collaboration played a central role in their classrooms, Richard identified it as "a growth area for me for sure." Vanessa, more specifically, noted struggles engaging the class in meaningful collaboration. For example, she identified her activities as discussion based, “It's all discussion based. I usually have like a series of questions that I'll ask them, and sometimes they'll break up into their groups and look at their data, and provide evidence for whatever statement they're saying.” She also pointed out, however, that these discussions were a means for extending learning on a particular topic, not for engaging in inquiry or the development of a broader project. Informal conversations about subject matter, a key ingredient in formulating a social learning environment (National Research Council, 2013) was not encouraged. She seemed inclined to believe that such conversations could be helpful but was not clear about how to support such collaboration.

In contrast to the survey data (see Table 2.5), teachers consistently identified the amount of time required to incorporate SCL practices in their instruction as a barrier during their interview. Richard, Madison, and Andy suggested that integrating technology and SCL practices really added to an already full workload and that integrating one project a semester represented an accomplishment due to the amount of content that had to be covered. Gloria agreed that the workload could initially be overwhelming. She further identified time as a very real barrier to doing projects or any other student-centered activity in class. She said:

> Setting all that up, making the videos and all that stuff took a tremendous amount of time initially. And then learning the programs … once I have it set up, forget it. Super easy. Saving me hours and hours and hours of time later. But initially, yeah. I think that's what turns a lot of teachers off.

Although these teachers expressed value in longer projects where students can research, plan, and execute a sophisticated solution to a problem, they do not see how it is possible with the amount of content they have to teach.

Vanessa, similar to Madison, Andy, and Richard, seemed to be torn between wanting to be more SCL-based in her practices and the need to ensure full coverage of her content. This perception that SCL practices take away from the ability to teach subject matter content is a common barrier to implementing SCL practices (Hannafin & Land, 1997). Of the teachers interviewed, only Ryan indicated that his students engaged in regular projects as a primary form of instruction. When asked about the barriers to this practice, he noted that the switch to SCL practices has been a long process that has required a lot of sacrifices. While he doesn't feel that his students are losing out on content in the long run, he also sees that he is not teaching as much content as deeply as he used to.

Discussion

In sum, the evidence examined in this chapter suggests that TEL was not being fully implemented within CMC classes at the time of the needs assessment study. Further evidence indicated that teachers saw a need for greater knowledge toward TEL and that some teachers exhibited significant concerns of how TEL practices could impact their professional practice and identity.

Although teachers saw TEL practices as already existing in their classrooms, data from the SSPLE and classroom observations did not support that conclusion. In particular, teachers universally indicated that their lessons were designed to support individual student progress, promote reflection and the development of self-assessment strategies, stimulate higher-order thinking, and provide opportunities for students to collaborate about issues relevant to their contemporary world. Evidence from classroom observations, however, demonstrated a much higher reliance on directed-learning techniques, especially lectures and the completion of low-level directed tasks such as worksheets. Data from teacher interviews suggest that this disconnect may be a result of a need for greater knowledge or understanding of SCL and its role in promoting learning.

An inconsistent understanding about SCL as well as complex beliefs and attitudes toward technology and student-centered practices likely played a role in the paucity of TEL at CMC. Interviews with case study participants as well as data from the STPLE indicated that CMC teachers needed support to develop their TPK and PCK related to TEL. Similarly, the data point to a complex set of beliefs and attitudes held by CMC teachers toward TEL. Although teachers generally valued incorporating technology within their instruction and believed that it helps foster collaboration and student engagement, many teachers also saw TEL practices impacting three critical areas of instruction: time, workload, and content. They saw TEL practices as requiring a considerable time investment, both in learning how to adequately design and manage lessons that incorporate these practices and in the amount of instructional time that is required for executing these lessons. These data also indicated a perception that switching to SCL practices or incorporating new technologies will significantly increase their workload, at least initially. Finally, several teachers expressed the belief that using TEL practices requires sacrificing content, as they will not be able to cover all of the material they previously covered.

In addition to these concerns, a few of the teachers expressed a deeper worry about incorporating TEL. In their view, the extensive use of technology changed their role in the classroom and their relationship with students. As students are often more familiar with technology, these teachers worried that greater technology use would result in students gaining additional power over instruction within the classroom. These concerns represented a significant threat to their professional identity and posed a barrier to implementing TEL in their classrooms.

For these teachers, technology represented the invasive species that Zhao and Frank (2003) discuss.

Teachers must be exposed to SCL practices in the context of technology before they can transfer that knowledge to the use of technology to the classroom (Casey & Davidson-Shivers, 2014; Hannafin, Hill, Land, & Lee, 2014). That transfer is essential for achieving the transformation of the instructional environment that technology has long been expected to achieve (Cuban et al., 2001; Oncu, Delialioglu & Brown, 2008; Horn, 2013). This transformation is central to implementing TEL (An & Reigeluth, 2011; Hannafin et al., 2014; Land & Hannafin, 1997). In order for this transformation to occur, however, teachers should to be exposed to specific SCL practices in an environment that uses technology in a meaningful way to drive the SCL practices (National Research Council, 2013; Putnam & Borko, 2000). As Desimone (2009) suggests, this exposure is most effective if it occurs within a context that is directly relevant to teachers' professional practice. They also should have directed support and collaboration that will both guide the development of their knowledge and improve their attitude and sense of efficacy toward TEL (Desimone et al., 2009; Mouza, 2009). Finally, teachers need to see this learning applied in a context that would allow them to transfer their experiences readily into the classroom (Garet, Porter, Desimone, Birman & Yoon, 2001; McKenney et al., 2015). These guidelines informed the development of the intervention proposal that is documented in the next two chapters.

Chapter Three

Teacher Cognition and Technology Integration

The literature reviewed in Chapter One identified that the knowledge, beliefs, and attitudes that teachers hold toward technology and instructional changes are the most proximal forces shaping their use of technology to support student-centered practices in the classroom. The evidence presented in Chapter Two suggests that teachers at CMC desire to develop a greater knowledge base for SCL practices as well as the use of technology to support those practices. In addition, some teachers hold negative beliefs and attitudes toward TEL practices, which create barriers to these practices. To address these barriers to TEL integration, this chapter investigates the most effective manner for designing teacher PD to support their knowledge, beliefs, and attitudes toward TEL.

Educators and researchers have long reported that most teacher training is ineffective particularly in regard to transforming classroom practices (Attia, 2014; Putnam & Borko, 2000). The large amount of information that tends to be delivered in these trainings can overwhelm teachers especially when delivered through lectures or other forms of direct instruction after participants have spent a full day teaching (Merinik, Meijer, Verloop, & Bergen, 2009). More significantly, these trainings are often divorced from the day-to-day work that teachers perform, leaving them without sufficient context to apply the new concepts or skills in a meaningful way within their instructional practices (Opfer & Pedder, 2011; Putnam & Borko, 2000). This is particularly true with regards to technology integration, where teacher training tends to be led by trainers who are experts on the technology but are not themselves teachers and lack the professional context for understanding how teachers will use new technology (Burkholder, 2012; Macià & García, 2016; McKenney et al., 2015).

This chapter examines the literature related to teacher learning, particularly as it relates to effective PD to support technology integration and SCL practices. It continues the process identified in Chapter One of using discipline inquiry to drive improvement (Bryk et al., 2015). Grounded in McKenney and colleagues' (2015) ecological framework for TEL as well as Mayer's (2009) cognitive theory of multimedia learning (CTML), this chapter examines those elements that are most conducive to supporting the development of teacher knowledge, efficacy, and positive attitudes toward TEL and the use of multimedia communication tools. Based upon the findings from the literature, I developed an SCL and multimedia-based PD program to support the development of TEL at CMC.

Theoretical Framework

The examination of literature to support teacher learning toward TEL is grounded in two interrelated models that have been developed to help researchers better understand the use of technology within the learning process and to help educators integrate technology effectively within their instructional practice. The ecological framework for TEL, proposed by McKenney et al. (2015), provides an instructional design frame for examining practices that support teacher learning toward TEL practices. Mayer's (2009) cognitive theory of multimedia learning (CTML), meanwhile, provides a lens to examine specific instructional practices that support the design and delivery of information within a TEL environment. Together, these theories create a unified lens to examine teacher cognition toward technology integration and guide the development of a program to support TEL integration within CMC classrooms.

Ecological Framework for TEL

The review of literature related to TEL integration discussed in Chapter One was grounded in EST (Bronfenbrenner, 1979), which created a conceptual structure for considering the underlying factors associated with the limited use of TEL at CMC. In a similar manner, the ecological framework for TEL developed by McKenney et al. (2015) creates a structure for investigating the specific instructional design considerations that support teacher cognition toward TEL. This model is grounded in situated learning theory (Brown et al., 1989; Lave & Wegner, 1999) and information processing theory (Miller, 1988), two theories that undergird many studies on teacher learning (Putnam & Borko, 2000). Relative to situated learning theory, the EST framework for TEL integration sees teacher learning as embedded within the context of the instructional environment and the experiences that teachers bring with them to the PD experience. At the same time, the model rests on an understanding of the cognitive capacities that teachers and other learners bring with them to the learning experience, including their existing knowledge and their ability to reason through, imagine, and map new learning, and build upon the memory processes and cognitive operations that are central to information processing theory. Through these lenses, this framework emphasizes six integrated domains of design knowledge needed to effectively support learning within a TEL environment as well as three strands of research on design that guide an understanding of the interactions within this integrated knowledge base.

McKenney and colleagues identify teaching, including the facilitation of teacher PD, as a design science with its own unique knowledge base. This knowledge base includes an understanding of the pedagogical practices that best support learners and their needs within a subject area (Shulman, 1987) as well as how to integrate digital technology to effectively communicate content and support learner-centered practices (Koehler & Mishra, 2005). They organize this knowledge base into six interrelated domains, as identified in Table 3.1. The first three domains (i.e., know-what, know-when, and know-how) emphasize knowledge related to the design of learning with technology. The know-where and know-who domains address teacher understanding of how to seek support for integrating technology. Finally, the know-why domain addresses teacher beliefs toward digital technology and the incorporation of technology within the instructional process. In this way, the ecological model for TEL addresses the core of teacher cognition (i.e., the knowledge and beliefs that teachers hold) as well as the design of PD to support teacher learning (McKenney, Boschman, Pieters, & Voogt, 2016).

Table 3.1
Domains of Teacher Knowledge Related to TEL

Domain	Description
Know-What	Teacher knowledge of the design process, the content the instruction is meant to address, and the technology they are seeking to integrate.
Know-When	Teacher knowledge of the learning process and how to sequence instruction to support that learning
Know-How	Teacher technological knowledge and how they go about increasing their skill with technology as well as pedagogical practices.
Know-Where	Teacher understanding of where frameworks can be found to guide the design process and where to find inspiration for design.
Know-Who	Teacher understanding of whom to work with in designing their lesson or to consult if they need guidance.
Know-Why	Teacher beliefs toward instruction and design, including how those beliefs and experiences shape their choices.

Note. The Ecological Framework for Technology Enhanced Learning includes eight domains of teacher learning grouped within three strands related to research on design. Adapted from “Teacher Design Knowledge for Technology Enhanced Learning: An Ecological Framework for Investigating Assets and Needs” by S. McKenney, Y. Kali, L. Markauskaite and J. Voogt, 2015, *Instructional Science*, 43 (2), p. 190. Adapted with permission.

The integrated knowledge domain identifies the aspects of knowing that enable instructional design. To better conceptualize the complex dependencies and interactions within this integrated knowledge base, however, McKenney et al. (2015) framed the knowledge base within an ecological model that emphasizes three strands of research on design: powerful design heuristics, teacher-design consciousness and experience, and realistic understanding of design practices. The design heuristics strand emphasizes design as a form of disciplinary knowledge that seeks to create a conceptual basis for supporting learning and includes the language, principles, and frameworks employed by instructional designers. The strand that focuses on teacher design-consciousness and experience, on the other hand, reflects the teacher's understanding of design as deeply embedded within the situated context of the instructional environment. As such, their experiences with technology and different instructional practices play an important role in the knowledge, habits, and routines that guide their design of instructional materials and practices. Finally, the strand that emphasizes realistic understandings of design practices focuses on the social capacities (e.g., collaboration, communication, and the sharing of design tools) of the learning environment as well as by cognitive capacities (e.g., reasoning, concept mapping, and PCK) of learners. Such capacities include an understanding of how to blend knowledge related to content, pedagogical practices, and technological knowledge (i.e., TPACK; Koehler & Mishra, 2005) to facilitate instruction as well as teachers' beliefs about how students learn, what content and skills are essential for learning, their pedagogical orientation, and the constraints or barriers they perceive with regard to technology.

McKenney et al.'s (2015) EST model for TEL integration, described here, frames several important considerations for the investigation into effective teacher PD within this chapter. The focus on design heuristics suggests the need to consider deeply the formal instruction that teachers need related to content, skill development, and conceptual knowledge to enact changes within their instructional environment that are consistent with TEL. The emphasis on teacher design consciousness, on the other hand, indicates the need to consider how teacher learning is situated, including the personal factors that influence their understanding of digital technology as well as new instructional practices. Meanwhile, the ecological strand related to realistic understandings of design suggests the need to identify the environmental parameters that support teacher learning, especially with regards to their learning with technology. Finally, the integrated knowledge base that McKenney and company identify suggests the need to frame the investigation on the core elements of teacher cognition (i.e., their knowledge, beliefs, and attitudes) toward TEL as well as the PD components that support each element.

As teacher learning to support TEL integration is the focus of this study, the EST model for TEL integration provides a strong instructional design lens through which to examine the literature related to teacher PD and technology integration. To better understand how to design and deliver content within a TEL environment, including one that addresses teacher PD, Mayer's (2009) Cognitive Theory of Multimedia Learning (CTML) is applied as a second frame for this investigation. Additionally, CTML served as a lens to guide the intervention and support participants to align their TEL instruction with this theory.

Cognitive Theory of Multimedia Learning

Just as a sociocultural lens of learning was applied in Chapter One to understand the social interactions and knowledge construction processes within the EST model, Mayer's (2009) CTML model provides a lens to understand the specific design and communication elements that support teacher cognition and TEL. Grounded in information processing theory (Mayer, 1996; Miller, 1988), a constructivist view of learning (Bransford et al., 2000; Piaget, 1959), and an understanding of learners' inherent cognitive load (Sweller, van Merriënboer, & Paas, 1998), CTML argues that instructional design should be informed by an understanding that (a) multimedia communication is a form of learning and that (b) people learn more effectively from images and words than from words or images alone (Butcher, 2014; Lajoie, 2014).

Building from the classic dual-memory model of information processing (Mayer, 1996), CTML stresses how verbal and visual information are processed in separate channels within working memory and that information that is received via only one channel will not be processed and stored in long-term memory as effectively as information that is received through both channels (Mayer, 2008; Paivio, 2014). Multimedia technology, thus, is a tool that helps learners organize and construct coherent mental representations to facilitate the memory-making process. The instructor using multimedia technology is a cognitive guide, supporting learners in their cognitive processing of multimedia images and building upon their knowledge to create a more complete and cohesive understanding of the information in a broader context (de Jong & Lazonder, 2014).

As Kirschner (2002) notes, however, this foundation must also be understood within the context of the inherent limits of working memory. This point was first articulated by Sweller (1994) who noted that if too much information is presented simultaneously or without proper cognitive foundations, the student will be unable to process the material effectively, creating immediate limitations to their ability to construct a deeper understanding of the material. DeLeeuw and Mayer (2008) expanded upon this theory of cognitive load to propose a triarchic model consisting of three types of cognitive processing: extraneous, essential, and generative. Extraneous processing includes elements of a presentation that distract from the objective of the presentation. On the other hand, essential processing includes elements that are required in order to move the objective information into working memory. Meanwhile, generative processing includes elements such as clear organization and references to prior knowledge that help the learner make sense of the information within the presentation. Understanding these processes can help reduce or eliminate barriers to processing multimedia messages (Mayer & Fiorella, 2014).

From these considerations on learning, Mayer (2009) identified ten principles of multimedia learning grouped under three main learning goals (see Table 3.2). Emphasizing the need to minimize cognitive load for the learner, the first goal stresses the need for multimedia messages to create coherence, reducing redundant information or images, establish signaling, and create contiguity within the presentation. The second goal, on the other hand, emphasizes the need to create a coherent though complex message through segmenting (i.e., breaking a presentation into smaller parts) and pre-training (i.e., providing main concepts at the start of the presentation) while using spoken rather than written text whenever possible. Finally, the third learning goal, fostering generative processing, emphasizes how to support deep cognitive processing through the use of multimedia design and careful consideration of the style and tone of the language within the presentation. Through these principles and goals, multimedia technology serves as a tool for fostering human cognition (Mayer, 2009).

Table 3.2
Main Goals and Principles of Multimedia Learning

Tenet 1: Reduce extraneous processing (i.e., eliminate information and other material that could be confusing or does not support the message being conveyed)
Coherence – eliminate unnecessary material
Redundancy – eliminate redundant text, narration, or graphics
Signaling – highlight essential material
Spatial contiguity – ensure that any text aligns with graphics
Temporal contiguity – present narration and graphics or animations at the same time
Tenet 2: Manage essential processing (i.e., present the message in a manner that balances simplicity and coherence with the needed complexity of the process being addressed)
Segmenting – present message in learner-paced segments
Pre-training – add pre-lesson components related to key components of the message
Modality – Present words as spoken text rather than written text whenever possible
Tenet 3: Fostering generative processing (i.e., deep cognitive processing such as organization of the message and integrating new material with previous knowledge)
Multimedia – present words and pictures rather than words alone
Personalization – present message in a conversational style rather than formal style

Note. The Cognitive Theory of Multimedia Learning identifies 10 multimedia principles organized within three main learning goals. Reprinted from "Cognitive Theory of Multimedia Learning", by R. Mayer, in *The Cambridge Handbook of Multimedia Learning*, R. Mayer (Ed.), 2014, p. 63. Copywrite 2014, by Cambridge University Press. Adapted with permission.

These tenets and principles of CTML suggest the importance of investigating not only the design of PD activities that best support teacher cognition toward TEL, as noted in the above discussion of the EST model for TEL development, but also the best way to present content and materials to teachers. This includes an investigation into the best multimedia tools to use in presentations as well as how to design those presentations to reduce extraneous processing, manage essential processing, and promote generative processing within participants. It also suggests the need to consider how different multimedia tools have been integrated into teacher PD and the contextual issues that have supported or hindered learning with those tools. Finally, the emphasis on multimedia learning as a sense-making process, in which learners actively construct their knowledge through visual and verbal information, suggests the need to more deeply consider how teachers can use multimedia tools effectively to deepen their understanding of TEL.

Together, the EST model for TEL integration (McKenney et al., 2015) and the CTML (Mayer, 2009) provide a framework for the review of the literature related to teacher PD to support technology integration and TEL that follows. This review focuses on studies that examine how to support the development of TCK, TPK, and TPACK (Chai, Kho, & Tsai, 2013), encourage changes in teacher attitudes toward technology integration (Saudelli & Ciampa, 2014), and build a stronger foundation for teachers to expand their learning with technology beyond initial PD (Chai et al., 2013; Voogt, Erstad, Ded, & Mishra, 2013). This frame of focus is especially important in light of the general ineffectiveness of teacher PD (Lieberman & Pointer Mace, 2009; Sava & Shah, 2015) and the centrality of both efficient communication and effective learning with digital technology in 21st-century learning (Bybee & Starkweather, 2006).

Teacher Professional Development to Support TEL Implementation

National and international studies have consistently shown that teacher PD has little, if any, significant impact on the instructional environment (National Commission on Teaching and America's Future, 2003; Lieberman & Pointer Mace, 2009; Sava & Shah, 2015). As far back as 1996, a longitudinal study by Darling-Hammond revealed the poor quality and impact of PD in American schools and more recent studies have shown little development since then in the national (Garet et al., 2001; U.S. Department of Education, 2012) or international arenas (Organization of Economic Cooperation and Development, 2009).

The results of the needs assessment study discussed in Chapter Two identified a need to address the knowledge, beliefs and attitudes (i.e., teacher cognition; Borg, 2003) that teachers hold toward instructional change as the central focus for development of TEL at CMC. As Putnam and Borko (2000) pointed out, most studies related to teacher PD fail to meaningfully address the cognitive aspects of learning and ignored the communities and environmental context where learning occurred. The remainder of this chapter will consider the literature related to effective PD, in general and as it pertains to teachers' knowledge and beliefs toward TEL, in order to guide the design of a teacher PD program to support teacher cognition toward TEL.

Characteristics of Effective Teacher PD

Traditionally, teacher PD is presented in short-duration workshops focused on a key strategy or new curriculum materials rather than empirically-based theories or cognitive science (Guskey, 2000). As Grossman (1990) pinpointed in a seminal work on teacher PD, this practice relies on teachers to go back and implement the strategy or material in isolation. Teachers and policy makers have consistently supported this model, partly from a belief that teaching is a process of trial and error within the classroom (Hoekstra, Brekelmans, Beijaard, & Korthagen, 2011) and partly from an implicit understanding that teaching is intuitive and based more on strong CK than pedagogy (Grossman, 1990).

Participation in such "hit-and-run" versions of PD, Ball and Cohen (1999) argue, is the equivalent to "yo-yo dieting" (p. 4), resulting in no significant impact or even negative impact on instruction. In their examination of teacher training programs and teacher PD, these authors noted how there is no clear infrastructure to guide teacher PD owing to the common perception that teaching is natural and that changes in teacher practices are the result of new standards and assessments, rather than the development of teacher knowledge and skills. They asserted that, to support instructional changes consistent with student learning, teacher PD needs to be grounded in PCK, developed through a clear theoretical foundation of learning, and situated in teachers' professional practice.

Putnam and Borko (2000) agreed, noting that teacher learning has frequently been forgotten in the quest to improve professional practice due to the assumption that teachers should primarily teach rather than learn. In their review of teacher learning, grounded in situated learning theory, they argue that effective teacher PD must see teachers as learners, able to grow and change in their knowledge and beliefs, and be situated in teachers' professional practice. As such, teacher PD should have clear relevance to teachers' professional practice and be centered on content that they can either impart to students or which they see as guiding their ongoing learning as teachers. Further, they suggest that although university-based PD has a role in imparting information to teachers, teachers are able to more effectively transfer their learning into their professional practice when at least some of the PD is located within their professional context (i.e., a school or classroom that is similar to their professional context).

In a similar manner, Opfer and Pedder (2011) identified, in a more recent review of teacher learning and PD, that the process-product logic that has dominated the literature on teacher PD is fundamentally flawed. In their words:

> the large amount of attention given to teacher professional development by researchers and policymakers has often rested on a process–product conceptualization of causality: that effective professional development will improve teacher instructional practices, which will result in improved student learning (p.384).

They further assert that teacher learning is more complex than other researchers have previously understood, due to the role that teachers play as facilitators of knowledge. Teacher learning, they therefore assert, is situated in teachers' past experience and understanding of the cognitive processes of learning, the environmental context of the school (i.e., the physical environment as well as the organizational culture and expectations within the school), and the learning activity that teachers are expected to participate in.

Coenders and Terlouw (2015) provide a sharper lens to this definition in their 2015 case study on the impact of teacher learning during changes in curriculum. They followed two sets of high school chemistry teachers who were adopting a new curriculum; one group who was involved in the design of the new curriculum and received PD to support that development and a second group that received the new curriculum without PD support. They framed their investigation within a model of teacher cognition that emphasized what teachers learn and how they learned it. The focus on what teachers learn addressed the cognitive aspects of teacher learning, including PCK, which is often underappreciated in the literature on teacher PD (Attia, 2014; Burns, Freeman, & Edwards, 2015), while the second question addressed how that learning occurs, which they identified as a more common focus within studies on teacher PD. Both groups included experienced and novice teachers who supported the new curriculum development and both groups were given time to review and enact the new curriculum within their classes following its development.

From interviews, questionnaires, and transcribed audio recordings from teacher meetings collected over a seven-month period, Coenders and Terlouw found that the teachers who served as the designers of the curriculum increased their PCK and acquired new beliefs that supported student learning. In contrast, the group that simply received the curriculum without helping to design it or receiving PD related to strategies to enact the curriculum within their classrooms did not report changes in their knowledge or beliefs. The authors noted that changes in the teacher-designers PCK was attributable to both their engagement in the active process of designing the curriculum as well as the PD support they received during the process, while their changes in beliefs were mostly attributable to their engagement in the design process. The researchers concluded that teacher PD should include activities in which teachers find value as a primary element within the teacher learning experience. Such activities are in line with what Grant and Branch (2005) refer to as authentic tasks.

In a similar manner, Garet et al. (2001) found that teachers need to be active participants in their learning to increase the effectiveness of PD. They used results from a national sample of 1027 mathematics and science teachers to compare the effects of different characteristics of PD on teacher learning. Data were collected from the Teacher Activity Survey administered by the Eisenhower Professional Development Program in 1999, and their analysis focused on the form, duration, and amount of collective participation that a given PD activity included. They found that several features of teacher PD had positive effects on teacher knowledge and changes in instructional practices, including active learning opportunities, coherence between the content of the PD and broader instructional mandates, and the ability of teachers to collaborate with other teachers.

Finally, McCaughtry, Martin, Kulinna, and Cothran (2006a, b), examined teachers' beliefs and attitudes toward PD as part of an investigation into effective teacher PD. Their study focused on 30 inner-city physical education teachers who were part of a grant that secured new equipment and PD to support the transformation of physical education curriculum. As part of the grant, the teachers received PD through workshops, peer learning communities, and visits by exemplary physical education curriculum mentors as well as sports equipment, texts, and instructional posters.

Data were collected through classroom observations and two 60 to 90-minute interviews with each participant. Among other findings, McCaughtry et al. (2006a) recorded that the novelty of the new equipment consistently excited teachers and helped them engage more fully in the instructional changes that were promoted within the PD. Additionally, they found that the PD elements reduced the isolation that teachers felt in their professional practice and made enacting changes a more positive experience even in the face of administrative resistance to changes (McCaughtry et al., 2006b). They concluded that PD should include opportunities for peer collaboration, focus on authentic experiences within professional practice, and introduce new materials or resources that teachers find interesting and relevant to their practice. These findings substantiate the literature on teacher knowledge and self-efficacy related to the importance of collaboration (Allan,Erickson, Brookhouse, & Johnson, 2010; Kellerer et al., 2014; Pan & Franklin, 2011) and authentic tasks (Coernders & Terlouw, 2015; Doering, Koseoglug, Scharberg, Henrickson, & Langgrang, 2014; Skoretz & Childress, 2013) within teacher PD.

The studies reviewed here provide broad insight into characteristics of effective teacher PD to guide the design of the teacher PD program within this study. They indicate that PD should to be designed to specifically support changes in participants knowledge, beliefs, and attitudes. They also point to how changes in teacher knowledge and beliefs should serve as the measurement of the effectiveness of the PD rather than student outcomes. The findings from these studies further indicated the need to situate the PD activities within the teachers' professional context, including the use of content and tasks that teachers find authentic to their practice and require them to be active participants in the learning process. With these principles in mind, the next section considers more closely the design of PD to support teacher knowledge, especially as it relates to TEL.

Influence of PD on Teacher Knowledge

As pointed out in the discussion of teacher knowledge in Chapter One, Shulman (1987) asserted that what teachers know reflects their CK, PK and PCK. In particular, PCK has been consistently identified as the core of teacher knowledge (Ball & Cohen, 1999; Grossman, 1990; Merinick et al., 2009) and the key to delivering high quality instruction (Hunter & Markman, 2016; Minor et al., 2016). Mishra and Koehler (2005) expanded this understanding to include the role of technology and the various types of knowledge inherent in TPACK. Together PCK, TPK, and TCK are consistently identified as the foundation of knowledge for teacher cognition toward technology integration in general (Macìa & García, 2016; McKenney et al., 2015; Minor et al., 2016; Mouza, 2009) and multimedia instruction in particular (Di Blas, Fiore, Mainetti, Vergallo, & Paolini, 2014).

To more deeply understand the impact of technology-based PD on participants' TPACK, Doering et al. (2014) provided 20 middle and high school social studies teachers with instruction related to GeoThentic, an online problem-based multimedia learning environment. Using geographic information system (GIS) technology, GeoThentic immerses participants in problem solving related to geographic problems, such as global warming, using built-in scaffolding elements including guided curriculum and videos. Thus, by using a combination of words and graphics, with a focus on authentic geography issues and grounded in situated learning, the program included many elements known to promote teacher TPACK as well as multimedia learning. Using a convergent mixed-methods design, participants completed pre- and posttest surveys, which included open response as well as Likert items. Data were also collected from a poststudy reflection. The week-long PD was conducted in the late summer, a couple of weeks before the start of school.

Using grounded theory to guide their analysis, three themes emerged from the data (Doering et al., 2014). The more participants used the digital learning environment the greater their self-reported technological knowledge base grew, including TK, TCK, and TPK. Teachers also reported perceived benefits associated with the use of authentic learning opportunities and that they associated those opportunities with increased CK and PCK. Participant reflections submitted four months after the program also revealed that teachers who engaged in the GeoThentic PD not only retained their knowledge from the workshop but transferred their knowledge to design and implement lessons using GeoThentic and other digital environments in their own classes. The authors determined that having teachers engaged in authentic learning opportunities using technology was essential for both their TPACK development and the transfer of knowledge into pedagogical practice.

The use of authentic learning experiences to facilitate TPACK development was also the focus of a study conducted by Allan et al. (2010). These authors investigated the use of a digital science program with K-8 teachers engaged in the EcoScienceWorks project, part of the Maine Laptop Program. Although the initial aim of the program was to provide engaging and challenging inquiry software with ecology content, the authors found that participants needed support to develop skills and knowledge to perform the anticipated tasks. They, therefore, established a PD program in which teachers would create curriculum that integrated the computer simulations into their teaching. Specifically, participants worked to develop the EcoScienceWorks curriculum to guide the use of the computer simulations as well as a complimentary hands-on field experience in ecology.

Twenty-three EcoScienceWorks participants spent three years working collaboratively with a digital science platform to build a set of lesson plans using the digital platform to share with other teachers in Maine. Data were collected each summer through surveys and interviews as well as regular observations of participants' interactions and their classrooms, collected in researcher journals. From these data, Allan et al. found that working with technology in a collaborative manner to address an authentic learning problem increased participant understanding of how to use technology, both on a mechanical level (i.e., they were able to use the technology more proficiently) and as a pedagogical tool for teaching (i.e., they successfully integrated technology to support new classroom practices). The learner-centered nature of the project also supported the growth of TPACK through active and authentic learning opportunities. Finally, they found that the teachers who collaborated the most also showed the greatest increase in TPACK development. This suggested that collaboration should be a substantive element in technology-based PD for teachers.

In contrast to the previous two studies, which sought to understand TPACK acquisition broadly, Minor et al. (2016) sought to understand the specific role that CK played in teacher PD. To achieve this, they conducted a randomized control trial with three groups of middle school science teachers. One group received science-specific content only; another group received the science content with additional training related to analytical thinking, the use of prior knowledge, and multimedia learning; and the third group as a control group who received no instruction. In addition to quantitative data from the broader study, the authors conducted two-hour interviews with 14 of the participant teachers, including at least four participants from each group.

Prior CK played an important role in the effectiveness of the PD (Minor et al., 2016). Those who had some prior knowledge of the content coming into the PD both understood the content better as well as applied the content through innovative pedagogical practices, even when they were part of the content-only group. They also found that CK played a role in the effectiveness of the cognitive science participants to understand and apply the new pedagogical principals. Those who had the stronger prior CK or who developed a strong understanding of CK through the PD were able to transfer the cognitive science principles to their instructional practice better than those who had weak CK. These results allowed the authors to affirm the primacy of CK as a building block for teacher learning as previously noted by Desimone (2009).

From these studies, several important notes informed the design of the PD program to address TEL development for the present study. As active learning is essential to TPACK development (Doering et al., 2014; Koehler & Mishra, 2009; Saudelli & Ciampa, 2014), teachers needed to be engaged directly with technology to address an authentic task. Based on the findings from Allan et al. (2010), the PD was designed so that teachers were engaged collaboratively in this active learning. Finally, the PD needed to focus on content that was engaging, related to teachers' practice, and related to topics that participants could connect to prior understanding (Minor et al., 2016). Such considerations are also important when supporting teacher beliefs, especially their sense of efficacy, toward TEL, as is discussed in the next section.

PD and Teacher Beliefs and Attitudes

As pedagogical practices shift, often in accord with policy decisions or new research about learning and teaching, teachers may encounter practices that are novel that may challenge their professional identity (Day, 2002; Overstreet, 2017; Yelland et al., 2008). When confronted with such situations, teachers are likely to fall back on their beliefs to guide their decisions (Nespor, 1987). Beliefs about education, however, are notoriously difficult to study as they often masquerade as other constructs (e.g., opinions, judgments, perspectives, etc.) and because there is no clear consensus regarding what constitutes a belief within educational psychology (National Research Council, 2013; Pederson & Liu, 2003).

Despite these concerns, however, the volume of literature concerning the impact of student and teacher beliefs on instruction has continued to grow (Howard, Chan, & Caputi, 2015). Previous studies related to teacher learning and cognition have examined the impact of teacher beliefs toward content (Mouza, 2009), new pedagogical practices and technology (Edwards & Hensien, 1999; Kopcha, 2012), orientation toward PD (Abbott, 2005; Scott & Mouza, 2007), and self-efficacy (Mouza, 2009; Ross & Bruce, 2007). From these studies, a tentative link between teacher beliefs and attitudes, knowledge, and ability to implement PD content within their practice has been consistently indicated (Neuman, 2016; Pederson & Liu, 2003); however, that link is not always direct (Ashton & Webb, 1986; Ertmer, 2005). In particular, any negative beliefs teachers hold toward new pedagogical practices and technology can represent a significant barrier to their learning during PD (Merinick et al., 2009; Opfer & Pedder, 2011).

As discussed in Chapter One, Palak and Walls (2009) demonstrated that the perceptions that teachers hold toward technology shape how that technology is used in instruction. Using an explanatory sequential approach, they collected survey data related to teacher philosophies toward instruction and technology from 118 teachers who had been part of a PD program offered by the Benedum Collaborative Professional Development Schools. They used the surveys to identify four case study participants and then collected data from those participants using classroom observations, lesson plans, written reflections, and a 60 to 90-minute interview. They found three consistent themes related to PD and teacher attitudes from these case studies. The first theme was that the inclusion of active teacher collaboration, particularly small groups of teachers working together, helped to make the PD engaging and supported improvements in teacher general attitudes toward technology integration. Teachers who demonstrated improvements in their attitudes toward technology also had been consistently involved in SCL-based PD. Finally, Palak and Walls discerned that teachers whose attitudes had improved often experienced PD that helped them to work through their limitations with technology rather than taking a one-size fits all approach.

In an effort to more fully understand the role of teacher beliefs and attitudes in the success of web-based PD, Kao, Tsai, and Shih (2014) developed the web-based PD self-efficacy (WPDSE) instrument. This instrument was constructed based on interviews with eight elementary school teachers. A comparison was then done using this instrument and an existing instrument, the attitudes toward web-based PD (AWPD) survey, with 214 elementary school teachers in Taiwan. The results validated the WPDSE and indicated that although teachers might hold mostly positive attitudes toward internet use for personal practices, such attitudes do not automatically translate into positive beliefs and attitudes toward technology use in instruction or as a method for PD. The authors suggest that PD be designed with introductory lessons that orient participants to the environment, identify specific and explicit expectations for use of a web-based platform, and include language that builds participant confidence in using web-based platform as an instructor. These findings are consistent with cognitive load theory (Sweller, 1994) and with Mayer’s (2009) CTML focus on reducing extraneous processing and supporting essential processing.

In recognition of the need for schools to create such technology-enriched learning environments, the Slovakian government instituted a national modernization program from 2008-2013 to increase the number of computers in schools and provided PD to support new instructional strategies. Karolčík et al. (2016) reported on the impact this program had on the beliefs and attitudes of 342 biology teachers who participated in a three-year PD program on instructional technology. All participants received equipment (i.e., a personal laptop computer, several desktop computers, a video projector) as well as a sequence of PD including a year of expert guidance related to MS Office, a year of multimedia training, and a final year of inquiry- or project-based activities. Focusing on participants in their final year, data were collected through an online questionnaire. Participants indicated that they were generally happy with the skills they were developing but were frustrated by the organization of the program in the first two years, which included a lot of direct instruction and a primary focus on technical skills. In contrast, teachers indicated a high approval rating for the guided activities that focused on biology content during that final year. This finding provides additional support for the assertion that teacher PD toward TEL should include authentic tasks that engage participants in using the technology in a manner that they find relevance in and can transfer to their instructional practice (Coenders & Terlouw, 2015; Putnam & Borko, 2000).

Several important lessons emerged from these studies on the impact of PD on teacher beliefs and attitudes toward technology integration. The findings from Karolčík et al. (2016) and Palak and Walls (2009) support the literature reviewed in the previous two sections on the importance of using technology-based tasks that are authentic to teachers (i.e., tasks that teachers find meaningful and see as directly related to their professional practice). Palak and Walls also suggest the need to offer teachers options in the platform or end product they create as a part of their PD learning. Finally, McCaughtry et al. (2006) and Palak and Walls (2009) point to the importance of participant collaboration in improving and maintaining teacher beliefs and attitudes toward technology.

Influence of PD on Teacher Efficacy

Self-efficacy is a specific type of belief that has been increasingly studied with regard to teacher learning and technology integration (Atif et al., 2015). Previous studies have indicated that self-efficacy serves as a mediator in the process of teacher learning and instructional change (Patrick & Pintrich, 2001; Rohaan et al., 2012). Such mediation occurs either by impeding change (e.g., if the learner has a strong sense that they cannot perform a task or a strong sense that the task can only be performed another way) or by facilitating change by creating a framework for understanding and validating the new information (Merinik et al., 2009; Ross & Bruce, 2007; Verloop et al., 2001). In this way, teachers' perception of their capability of enacting change serves to support or weaken their ability to fully engage in the teacher learning process (Day, 2002; Rohaan et al., 2012). Similarly, teachers' perception of their ability to use and integrate technology has a strong impact on the success of technology-related PD, especially as it relates to translating the PD into instructional change (Kellerer et al., 2014; Ross & Bruce, 2007; Watson, 2006).

The International Association for K-12 Online Learning (iNACOL) found evidence of increases in teacher efficacy in using online and digital technology in a study with 900 teachers in Idaho who participate in online PD (Kellerer et al., 2014). The authors identified teachers who indicated that they had participated in some form of online PD training, either in a 100% online environment or in a blended-learning environment and identified 19 who had also participated in Idaho Digital Learning Academy PD training. Those participants were contacted, and eight agreed to be interviewed about their experiences as a learner in an online setting and how that impacted their ability or desire to integrate online learning within their instructional practice.

The teacher interviews revealed that these teachers felt more confident in their ability to continue integrating technology into their instructional practice after their participation in the online PD. A deeper look into the data identified two factors that contributed to their increased self-efficacy. One factor was the timeliness of the training, coming at a moment when these teachers were interested in learning more because other factors had helped them to see a need for greater technology integration. Of further importance was the collaborative support these teachers experienced in both the training and in implementing blended learning in their classrooms. The teachers reported that collaboration allowed them to "solve problems as well as share [their] successes and … get excited and feed off one another, and help one another when necessary" (Kellerer et al., 2014, p.13). This shared experience helped teachers to be more confident in their ability to complete the program, as well as transfer the learning to their classroom.

Blended learning can be implemented using a wide variety of tools, and the iNACOL report did not specify the digital tools that defined the technological environment in their study. In contrast, Skoretz and Childress (2013) focused exclusively on the use of one digital tool, wiki's, in their study of a school-based teacher PD to support technology integration in a problem-based setting. Sixty-five elementary and middle school teachers participated in either an experimental or control group. Both groups received the same instruction on the use of wikis as an instructional tool, a review of Grappling's Technology and Learning Spectrum, an instructional framework that outlines three levels of technology use for instruction (i.e., literacy use, adaptive use, and transformative use), and guidance through the problem-based activities to enhance skills in creative thinking, collaboration, and problem solving. Following the instruction and presentation of the problem, the participants worked collaboratively to construct a one-minute public service announcement addressing the problem. Additionally, the experimental group engaged with specific prompts that encouraged reflection and peer support, two factors that Doering et al. (2014) and Kellerer et al. (2014) suggested were helpful in promoting efficacy with technology. Data were collected from the wiki posts as well as from a pre and post application of the Computer Technology Integration Survey (Wang, Ertmer, & Newby, 2004). The wiki posts were scored along a previously developed Technology and Learning Spectrum and those scores were combined to provide additional quantitative data.

Evidence from the experimental group demonstrated an inverse correlation between years of experience and efficacy toward technology integration as well as a difference between elementary and middle school teachers, with middle school teachers demonstrating a higher sense of efficacy. The experimental group did not, however, demonstrate a significant improvement in their self-efficacy over the control group; both groups indicated a moderate improvement in efficacy related to their capabilities and strategies with instructional technology. Skoretz and Childress concluded that more technology-based PD was needed to support teachers in building their sense of efficacy toward using technology and facilitating technology integration.

Skoretz and Childress (2013) noted two significant limitations in their data collection and analysis that provide some guidance for the current study. The first was that the Grappling's Technology and Learning Spectrum's restriction to three broad categories likely hid some aspects of change in technology use that might have been visible if the data were analyzed with an instrument that included more categories. The lack of specificity, in other words, meant that smaller changes in technology use went unobserved. Additionally, they found their reliance on wiki posts limited the analysis they could perform and decreased the accuracy of their analysis.

As the posts are all self-reported data, participants could shape the lens that was being used to investigate the instructional technology use, in effect hiding aspects that they didn't want to discuss. The authors conclude that this likely created a distorted sense of participants' efficacy. They suggested that future studies include classroom observations to help create a fuller picture of how technology was used by teachers in their instructional practice.

Whereas Skoretz and Childress (2013) pursued an examination of the immediate impact of technology-based PD on teacher efficacy, Watson (2006) sought to understand the long-term impact that technology-driven PD could have on teachers' sense of efficacy toward technology integration. To accomplish this, he used the results of the West Virginia RuralNet Project, which ran from 1995-1999 and was designed to provide PD related to internet use in West Virginia public schools. The components of this program included a focus on skills such as email use, searching the Web, downloading material and applications, and integrating web tools into their instruction. Watson identified 296 of the 389 teachers who participated in the project during the 1996-1997 school year and were still employed in West Virginia schools in the 2002-2003 school year, six years after the initial study. He surveyed those teachers, and 97 of them completed the Personal Internet Teaching Efficacy Beliefs Scale survey, which had also been used at the beginning and end of the RuralNet project.

Watson compared these data with the original survey data and concluded that the participants had sustained growth in teacher efficacy throughout the program. This was particularly manifest in questions related to technology use and substantiated by the fact that almost all of these teachers had sought out and participated in additional technology-related PD after the program. By engaging in extensive use of the internet and internet tools during the original PD, teachers had not only increased their sense of efficacy but maintained that sense of efficacy and become more self-directed in their learning toward technology integration.

As Web 2.0 tools began to reshape the learning potential of the Internet at the outset of the 21st century, teachers were increasingly tasked to not only integrate technology but to do so in increasingly student-centered manners. Pan and Franklin (2011) sought to understand how that shift impacted teachers' sense of efficacy toward instructional technology as well as the potential for PD with Web 2.0 tools to maintain or increase teacher efficacy. They conducted a national survey of 559 in-service teachers, using two instruments specific to Web 2.0 tool integration, the Web 2.0 Tools Integration and Self-Efficacy Instruments.

Most participants indicated that they never used specific Web 2.0 tools, such as blogs or cloud-based documents, as a result of a lack of training in the use of the tools as well as low confidence in their ability to use the tools in an instructional manner. For those who did integrate Web 2.0 tools, a multiple regression analysis revealed that PD using the Web 2.0 tools was the primary influence leading to that use. Further, the time they spent in PD with Web 2.0 tools to collaborate, solve problems, or create artifacts related to a specific content focus was positively related to their confidence about their use of the tools to support student learning.

The studies identified here depict the importance of ongoing teacher participation with technology especially in a PD setting where they can receive direct support for supporting teacher efficacy toward technology integration. The results from the iNACOL report (Kellerer et al., 2014) and Pan and Franklin (2011) point to the importance of teacher collaboration as part of that participation, meanwhile Watson (2006) and Skoretz and Childress (2013) demonstrate the need for teachers to be active learners with technology. Pan and Franklin's (2011) study provides additional insight into the need for teachers to engage in learner-centered instruction as part of their training with technology, which is also important for modeling instruction in a TEL environment (An & Reigeluth, 2011). Finally, the iNACOL report also points to the importance of the timeliness of the PD instruction with technology; teachers need to be ready to take the step toward greater use of technology. All of these are important factors that informed the development of the PD program to promote TEL at CMC that is central to this study.

Discussion

The studies reviewed in this chapter suggest that teacher PD focused on design knowledge for and application of TEL has the ability to influence teacher knowledge, beliefs, and attitudes in both positive (Allan et al., 2010; Pallak & Walls, 2009; Watson, 2006) and negative ways (Kao et al., 2014; Skoretz and Childress (2013). They support the importance of having participants build a conceptual knowledge base for design, instruction, and technology use. A deep conceptual knowledge base not only serves to help teachers transfer their learning into their instructional practice (Minor et al., 2016), it also is critical to improving their attitudes and sense of efficacy (Skoretz & Childress, 2013). Studies by Doering et al. (2014) and Pan and Franklin (2011) demonstrate the importance of teachers spending extended time learning with and working with digital tools related to instruction. Although much of the attention in this area is focused on the amount of time teachers spend using specific digital tools (Cuban et al., 2001; Rohaan et al., 2012), the results from Allan et al. (2010) and Doering (2014) also point to how directed instruction on the use of specific tools as well as the support of vicarious learning experiences can also help teachers build a TPACK knowledge base.

In addition to building teachers' knowledge base for design, instruction, and technology use, these studies also suggest the need to engage teachers in authentic tasks. For example, Allan et al. (2010) and Doering et al. (2014) note how tasks that teachers find applicable to their instructional practice are more effective at increasing their knowledge. Similarly, Watson (2006) identified the importance of connecting PD content and tasks to teachers' professional practice in order to increase their efficacy toward new pedagogies or practices. McCaughtry et al. (2006a, b) and Karolčík et al. (2016) further provided evidence that authentic tasks are critical to increasing teacher attitudes toward proposed changes, making it more likely that the changes would be implemented within the classroom. Finally, Allan et al. (2010), Skortez and Childress (2013), and Palak and Walls (2009) identified a direct connection between the use of authentic tasks and a more student-centered orientation toward instruction. The use of authentic tasks, therefore, is considered important to building teacher design capacity (McKenney et al., 2015) and knowledge construction (Mayer, 2009) toward TEL implementation.

The studies examined in this chapter also indicate a need to consider cognitive load when designing teacher PD. Minor et al. (2016), for example, demonstrated how connecting new learning with technology to teachers' prior knowledge helped them to better understand the new material and be able to transfer it to their instructional practice. Kellerer et al. (2014), meanwhile, in line with the principles of contiguity (Mayer & Fioreella, 2014), noted the importance of timeliness in teacher PD. Kao et al. (2014) similarly identified the need to structure PD so that participants can be easily oriented to the learning environment and emphasized the use of contiguous language to support teachers learning through the program. The findings from Skoretz and Childress (2014), meanwhile, imply a need to focus PD on essential elements and reduce extraneous information or activities.

Finally, several studies indicate the value of multimedia learning and instruction within the context of teacher learning. Doering et al. (2014) demonstrated how the inclusion of graphics and words within teacher training promoted both retention of information as well as transfer of learning into the instructional environment. Pan and Franklin (2011) similarly noted that although most teachers do not use digital multimedia tools to promote learning, effective PD that is grounded in research and theory was a common variable for those teachers who did integrate such multimedia tools to promote student learning. Palak and Wells (2009) and Karolčík et al. (2016) meanwhile demonstrated how active teacher participation in PD that teachers see as directly related to their instructional practices supports technology integration, in line with the assertions made by Paas and Sweller (2014) related to reducing and accounting for cognitive load during multimedia learning. These studies suggest that a focus on multimedia learning and instruction can serve as a focal lens for promoting the implementation of TEL instruction.

Collectively, the studies examined in this chapter point to four elements that will be included in the PD to promote TEL at CMC: (a) active learning with technology; (b) a learner-centered model of instruction; (c) participant collaboration; and (d) a focus on multimedia learning and instruction. With this in mind, I implemented a two-stage teacher PD program to help address TEL integration at CMC. In the first phase participants received directed instruction related to SCL practices while, simultaneously, being introduced and evaluating different modalities of multimedia communication. In the second phase teachers applied their learning to create a multimedia presentation of their own. Chapter Four explains this intervention, and the design of the study to examine its effectiveness, in full detail.

Chapter Four

Intervention Procedure and Program Evaluation Method

Although the integration of digital technology in a manner consistent with student-centered pedagogies is central to 21st-century learning (Cuban et al., 2001; Gunn & Holingsworth, 2013) evidence from a needs assessment study at CMC indicated that teachers saw a need for additional knowledge regarding TEL as well as support in developing beliefs and attitudes that can facilitate such practices. As was reported in Chapter Three, PD designed to support TEL integration should have an instructional focus that directly addresses the elements of SCL and models SCL practices as well as facilitates extended exposure and use of digital technology (Allan et al., 2010; Doering, et al., 2014). Using Mayer's (2009) cognitive model for multimedia learning and McKenney et al.'s (2009) model of instructional design for TEL as guides, this chapter describes an intervention that was implemented to address teacher cognition toward TEL implementation at CMC.

Purpose of the Study

The purpose of this study was to examine the effects of a teacher PD program, focused on SCL pedagogies and multimedia design, in supporting the implementation of TEL instructional practices at CMC. Prior research (see Chapter Three) suggests that such a program should support teachers' knowledge, particularly TPACK, as well as their beliefs and attitudes toward technology-enhanced learning leading to implementation of TEL in participant's classes.

The research questions for the study addressed both the fidelity to which the program was implemented (Dusenbury, Brannigan, Flaco, & Hansen, 2003) as well as the extent to which the program achieved its proximal goals of supporting teacher cognition and implementation of TEL. These questions included:

Process Research Questions

RQ1: Was the PD program implemented with fidelity (Dusenbury et al., 2003), including program adherence, dosage, quality of instruction, and participant responses?

Outcome Research Questions

RQ2: What changes in knowledge do participants evidence with regards to SCL practices, presenting content through different forms of multimedia technology, using digital multimedia technology to facilitate SCL practices, and using SCL practices and multimedia technology to facilitate student learning within their content area?

RQ3: What change in attitudes and beliefs do participants exhibit with regards to SCL, digital technology as an instructional tool, and their sense of efficacy toward TEL instructional practices?

RQ4: How do participants implement TEL practices within their instructional practice?

Research Design

I implemented a convergent mixed-methods design (Creswell & Plano Clark, 2011) similar to that used to guide the needs assessment study, during the Fall 2018 semester. As TPACK has proven particularly difficult to measure through quantitative methods (Koehler, Shin, & Mishra, 2012), qualitative data sources were more dominant within this study. Quantitative sources, however, supported an investigation into the intervention's impact on participants' learning and beliefs. The inclusion of both types of data also supported triangulation, increasing the validity of the overall findings and offsetting any weaknesses in either type of data (Johnson & Onwuegbuzie, 2004). The causal model guiding the intervention (see Appendix I) depicts the relationship between the core elements of the program, how they support teacher knowledge, attitudes, and beliefs, and the short- and long-term outcomes the program is intended to support. The following discussion details how the process and outcomes of the intervention were evaluated in line with this causal model.

Program Evaluation Plan

Program evaluation is the systematic process of determining the extent to which a program was effectively implemented (i.e., process evaluation) as well as the extent to which it achieved its goals (i.e., outcome evaluation). This includes a detailed consideration of the participants the program was designed to serve, how the factors to ensure the program operated as designed were monitored, and how the intended outcomes of the program were monitored and measured. The research matrix for this study (Appendix J) provides a synopsis of the plan that I implemented as well as the methods used for collecting and analyzing the data to evaluate the program and its outcomes.

Process evaluation. At its heart, process evaluation involves examining the extent to which a program was implemented in a manner consistent with its design (Rossi, Lipsey, & Freeman, 2004) as well as capturing the lived experience of participants (O’Donnell, 2008). Dusenbury et al. (2003) identify five factors to measure the fidelity of implementation, of which program adherence, dosage, the quality of instruction, and participant responsiveness, were most relevant to the current study. Program adherence, for this study, included the delivery of five PD sessions addressing different elements of SCL through separate multimedia presentations as well as participant creation of a multimedia presentation. I also kept a reflective research journal (Drummer, Cook, Parker, Barrett, & Hull, 2008) to capture this process including entries for each interaction leading up to and following each training session as well as email correspondence with participants and the school principal.

Dosage was operationalized as the amount of time participants engaged in the program as indicated by their attendance to training sessions. I used my research journal as well as exit surveys (Appendix K) to capture dosage. Exit surveys and participant responses within a focus group interview also provided evidence to evaluate quality of instruction (i.e., participant perceptions of the effectiveness of the instructor who delivered the program content) as well as the extent to which participants engaged in and found value in the activities and content of the program (e.g., participant responsiveness). Prior research has indicated that exit surveys provide formative feedback on instruction (Wong & Glass, 2005), are especially valuable in improving teacher PD (Melber & Cox-Peterson, 2005), and provide a key indicator of whether or not the program reaches and meets the needs of its target population and the objectives of the theoretical model that guides the study (Rossi et al., 2004).

Outcome evaluation plan. The outcome evaluation plan for this study involved pre- and posttest surveys and interviews along with periodic classroom observations in case study participants classes to measure changes in participants' knowledge, beliefs, and attitudes; the extent to which those changes could be attributed to the program; and the extent to which those changes impacted classroom practice. The anticipated outcomes for the program, included increases in participant PCK, TCK, TPK, and TPACK, as well as improved attitude and beliefs, especially self-efficacy, toward TEL instructional practices (see Appendix I). I evaluated outcomes, such as changes in participants' perceived knowledge, sense of efficacy, and attitudes from two surveys, focus group interviews, and classroom observations. Classroom observations and focus group interviews also provided insight into how participants implemented TEL within their instruction, as implementation of new pedagogical practices is indicative of changes in teacher attitudes and beliefs, especially their sense of efficacy toward those changes (Guskey, 2002; Scott & Mouza, 2007). Evidence of implementation, therefore, served as an indicator of the overall outcome of the program.

Method

Within this section I detail how participants were selected, the study measures, and the procedure that was followed, including a description of the PD program and the methods used to collect and analyze data to evaluate the program.

Participants

My target population for this study were the 12 teachers at CMC, which was an increase in one teacher since the needs assessment study. All of the teachers, excluding myself, were invited to participate and 10 agreed to participate. The two teachers who chose not to participate in the study were still invited to attend the training sessions but no data were collected from them.

Table 4.1 lists participants' self-reported demographic information, including their years of experience and the discipline and grade-level of their primarily teaching. Six of the participants were male (60%) and all but one reported having more than 10 years of experience in teaching, with five of the participants reporting having more than 20 years of teaching experience. The entire English, mathematics, and science departments were represented in the study, while only one member of the social studies department participated. As the teachers are organized by grade-level teams, and the 10th-grade team was the only team which had participants from all four disciplines taught at CMC within the study, those teachers were selected to serve as case study participants for classroom observations.

Table 4.1
Participant Demographics

Gender	Years of Experience	Discipline	Grade-Level
Male	5-10	Mathematics	10
Female	More the 20	English	9
Male	More than 20	Mathematics	9
Male	11-15	Social Studies	10
Female	More than 20	Science	10
Male	11-15	English	11
Female	More than 20	English	12
Male	11-15	Science	9
Male	15-20	English	9
Female	More than 20	English	10

Subjectivity. As this study was conducted at the school in which I am a teacher, it is important that I address my own subjectivity in this study. I have been a teacher at CMC for fifteen years and have worked closely with all of the participants over that time. I am friends with many of them. As such, I am privy to personal and professional knowledge of each participant that is atypical for a researcher. This knowledge could have influenced how I analyzed the qualitative data that were collected, allowing me to perceive patterns that are not implied from the data or interpret the words of participants in a manner different from what is stated.

In addition to my teaching duties I have also served in a variety of leadership positions, including as a professional development coach, as the chair of our accreditation self-study process, and as the point person in the development of our system of grade-level teams. Combined with my personal connections with participants, this leadership role may have encouraged participation by some teachers who would otherwise not have been willing to participate in the intervention or to allow me to conduct observations in their classroom. It may also have created a level of personal obligation to complete both stages of the intervention that would not otherwise be present.

Measures and Data Sources

I evaluated program adherence, dosage, the quality of instruction, and participant responsiveness from data gathered through my research journal and exit surveys, as well as focus group interviews. Changes in participant knowledge, attitudes, and beliefs were measured using surveys, focus group interviews, and observations. Each instrument is discussed in detail below. The Research Matrix (Appendix J) provides each research question, construct, measure, data collection, and data analysis for the evaluation of this study. A cognitive interview was conducted with two non-CMC teachers to review each instrument and ensure that the meaning of the prompts within each instrument was clear and understood as intended. Additionally, at least three Johns Hopkins University faculty, including one expert on TPACK, reviewed each instrument to ensure content validity.

Process evaluation instruments. To evaluate the implementation of the program, I collected data from exit surveys and focus group interviews conducted at the conclusion of each stage of the intervention. I took field notes to capture details relative to teacher participation and responses at training sessions, participant questions between training sessions, and the multimedia presentations that participants engaged with during the application stage of the program.

Exit surveys. The exit survey I used in this study (see Appendix K) was adapted from a template used by the Baltimore City Public Schools for teacher PD (Baltimore City Public Schools, 2012) and was designed to gather data on participant perceptions of their learning at end of each stage of the program. There were two forms of the instrument, one for each stage. Both versions included five yes-no questions, which asked participants to identify the specific training sessions in which they participated. The instrument also included nine Likert items that measured responses related to the quality of instruction. For example, participants were asked how strongly they agreed that the facilitator was knowledgeable or that the trainings they received was relevant to their instructional practice. Finally, the instrument included three open-ended responses to measure participant responsiveness through prompts such as "the element or experience from this training that I feel will be most useful to me as a teacher was…" and "my biggest frustration with the program so far has been..." Table 4.2 details the constructs addressed by the exit surveys as well as the items and sample questions related to each construct.

Table 4.2
Exit Survey Constructs, Item Numbers, and Sample Questions

Construct	Definition	Items	Sample Questions
Dosage	The amount of the training per participant.	1-6, 19-22	Please indicate which sessions you participated in by selecting YES or NO next to the session description.
Quality of instruction	The extent to which participants see the trainer as knowledgeable and effective at delivering program content.	7-11, 23-27	The facilitator of the trainings I attended was engaging.
Participant responsiveness	The extent to which participants are engaged and find value in the activities and content of the program.	3, 16, 30	The training I received over the past several weeks was relevant to my instructional practice.

Focus group interviews. I captured the lived experiences of participants in this program through two semi-structured focus group interviews (Appendix L). The interview questions were adapted from protocols previously developed to investigate teacher TPACK (Christman, 2014; Saudelli & Ciampa, 2014), efficacy toward technology integration (Williams, 2013), and attitudes and beliefs toward instructional change (Christman, 2014; Swars & Chestnut, 2016). For example, one of the interview prompts asked participants “what are the best strategies for supporting student learning in your classes?” I constructed additional questions related to participant experiences within the PD program from guidelines suggested by the Communities for Public Health (2016) for interviews conducted as part of program evaluation. One such prompt asked participants “thinking about your experience in this program, including the instruction on student-centered learning, the use of multimedia tools for presentation, and the design process for creating a presentation, what was most valuable to you as a teacher?” Table 4.3 details the constructs addressed by the focus group interviews, along with the items and sample questions related to each construct.

Table 4.3

Focus Group Interview Questions Constructs, Item Numbers, and Sample Questions

Construct	Definition	Items	Sample Question
Participant responsiveness	The extent to which participants are engaged and find value in the activities and content of the program.	4	Thinking about your experience in this program, including the instruction on student-centered learning, the use of multimedia tools for presentation, and the design process for creating a presentation, what was most valuable to you as a teacher?
PCK	Knowledge of pedagogy that is specific to a teachers’ content area (Koehler & Mishra, 2009).	1, 5	Thinking only about your subject (such as English, math, science, or history) what are the best strategies for supporting student learning in your classes?
TCK	Knowledge of specific technologies that are best suited for addressing subject matter learning within a content area (Koehler & Mishra, 2009	2, 6	What kind of technology do you most often integrate in your lessons?

TPK	Knowledge of the pedagogical affordances and constraints of technology as a learning tool (Koehler & Mishra, 2009)	2, 6	How can you best integrate technology to support such student-centered learning? Are there any particular tools that you think are most helpful?
Teacher Beliefs About TEL	The personal convictions teachers hold about new pedagogical practices or students' use of technology to support those practices.	3, 5, 7	To what extent do you agree or disagree with the need to change your instructional strategies or to integrate more digital technology into your instructional practice?
Teacher Attitudes Toward TEL	Teachers expressed thoughts and perceptions about new pedagogical practices and the role of technology in supporting student learning.	3, 5, 7	What aspects of student-centered learning do you think you will use in future classes?
Teacher Self-Efficacy Toward TEL	Teacher confidence in their ability to integrate new pedagogical practices as well as integrate technology to support SCL practices.	3, 5, 7	How confident are you that you have the knowledge, skills and abilities to support students' use of technology to use technology and teaching strategies to personalize learning activities for students?

Outcome evaluation instruments. To evaluate the outcomes of the study, I used the focus group interviews described above along with two surveys, a modified version of the TTF-TPACK survey (Jamieson-Proctor et al., 2013) and an open-ended questionnaire that I created for this study, as well as classroom observations guided by the use of a technology observation checklist (Wong et al., 2014) within case study classrooms.

Teaching Teachers for the Future-TPACK survey. The 90-item Teaching Teachers for the Future TPACK survey (TTF-TPACK) was developed by Jamieson-Proctor et al. (2013) to measure teacher TPACK. They reported an initial alpha of .97 for both scales of the instrument. Cavanagh and Koehler (2013) noted, however, the instrument is focused on the perceptions of teachers, including their sense of efficacy toward TPACK. I, therefore, used a modified version of this instrument (see Appendix M) to assess teachers' attitudes and beliefs, including their sense of efficacy, toward TEL. From the 90 statements in the original instrument, I identified 20 that were directly relevant to teacher attitudes and beliefs, including self-efficacy toward TEL (see Table 4.4). Additionally, I clarified some of the language to support participant understanding. In particular, the term Information Communications Technology (ICT) is not a term used elsewhere in this study or commonly used amongst the CMC community when referencing computer technologies and was switched to "technology". Similarly, the original stem for each set of questions included language that conflicted with the individual prompts (e.g., the original stem for the first set of questions was "how confident are you that you have the knowledge, skills and abilities to support students' use of ICT to…" and the first prompt read "demonstrate knowledge of a range of ICT to engage students".) In effect, this statement was asking teachers to rate their ability to use technology to support students in engaging themselves. I thus modified the stem for both sets of prompts to ensure readability without changing the original intent of the statements. Following the administration of the survey, alpha scores for both scales were calculated at 0.96 and 0.955 for the pre- and posttest confidence scale and 0.945 and 0.917 for the pre- and posttest usefulness scale.

Table 4.4

Teaching Teachers for the Future TPAK (TTF-TPAKC) Survey Constructs, Item Numbers, and Sample Questions (Jamieson-Proctor et al., 2013)

Construct	Definition	Items	Sample Question
Teacher Beliefs About TEL	The personal convictions teachers hold about new pedagogical practices or students' use of technology to support those practices.	2, 4, 6, 12, 14, 16	How useful is it for you, as a teacher, or for your students to actively construct their own knowledge in collaboration with their peers and others?
Teacher Attitudes Toward TEL	Teachers expressed thoughts and perceptions about new pedagogical practices and the role of technology in supporting student learning.	11-20	How useful is it for you, as a teacher, or for your students to design technology activities that enable students to become active participants in their own learning?
Teacher Efficacy Toward TEL	Teacher confidence in their ability to integrate new pedagogical practices as well as integrate technology to support SCL practices.	1-10	How confident are you that you have the knowledge, skills and abilities to support students' use of technology to use technology and teaching strategies to personalize learning activities for students?

TPACK Survey. The various constructs that make up TPACK have proven difficult to differentiate and measure through quantitative methods (Chai et al., 2011; Koehler et al., 2012). As of yet, no quantitative instrument has been developed and validated that reliably measures TPACK knowledge construction, though various instruments have proven successful in measuring attitudes, perceptions, and behaviors related to TPACK (Cavanagh & Koehler, 2013; Chai et al., 2013; Jamieson-Proctor et al., 2013). Open-ended questionnaires, however, have been successfully used to measure most aspects of TPACK (Koehler et al., 2012). Therefore, I developed a survey of primarily of open-ended questions that was used in this study to measure PCK, TPK, TCK, and TPACK (Appendix N). I also included two sets of Likert scale questions to measure teacher experience with and self-efficacy beliefs toward the specific digital tools that were used in the intervention study. Following the administration of the instrument, alpha scores for the experience scales were calculated at 0.869 for the pretest and 0.862 for the posttest applications, while the confidence scale had a score of 0.92 for both the pre- and posttest applications. Table 4.5 details each construct measured through this instrument as well as the items that address each instrument and sample questions.

Table 4.5

TPACK Survey Constructs, Item Numbers, and Sample Questions

Construct	Definition	Items	Sample Question
PCK	Knowledge of pedagogy that is specific to a teachers' content area (Koehler & Mishra, 2009).	4	What instructional practices or strategies are particularly well suited to instruction within your subject area (you may focus on one or multiple options, at your discretion)?
TCK	Knowledge of specific technologies that are best suited for addressing subject matter learning within a content area (Koehler & Mishra, 2009	5	What digital technologies (i.e., websites, presentation tools, video creation tools, word processers, etc.) are best suited for teaching content within your subject area?
TPK	Knowledge of the pedagogical affordances and constraints of technology as a learning tool (Koehler & Mishra, 2009)	6, 8-12	In what ways can technology support the teaching process or help make learning more effective?
TPACK	Knowledge of how to represent concepts with technology, how technology can be used to make such concepts easier to learn, how technology can be used to build upon students' prior knowledge to build new knowledge, and the pedagogical techniques that use technology to constructively teach content (Koelher & Mishra, 2009)	7	How has a particular piece of technology supported students in learning the content in your classes?
Teacher Efficacy Toward TEL	Teacher confidence in their ability to integrate new pedagogical practices as well as integrate technology to support SCL practices.	13-17	How confident are you that you can use digital animation tools?

Technology observation checklist. I recorded field notes during each non-participatory classroom observation session using a modified version of the Technology Observation Checklist (Wang, Hsu, Reeves, & Coster, 2014) (Appendix O). The checklist was designed to identify the classroom technology available in the classroom, classroom organization to support technology use, teacher support for student use of technology, instructional activities conducted in the class session, and technological support to learn the intended content. Wang et al. reported an inter-rater reliability of 0.9 for this instrument in their study of teacher PD to enhance the use of technology as cognitive tools.

Procedure

In the following sections, I provide a description of the process used to conduct the study, including PD program timeline, the steps taken to validate the instruments, and the process to collect and analyze the data. The full intervention is summarized graphically in the Intervention Matrix (Appendix P), and the research process is summarized in the Research Matrix (Appendix J).

Intervention

This study focused on a PD program that used instruction on SCL practices, collaboration with multimedia technology, and a design framework to support teacher cognition toward TEL integration at CMC. During the course of the program, participants progressed from guided instruction and discussion about the content to application of the content and skills. The causal model for this study (Appendix I) hypothesized that as participants progressed through the stages of the PD they would better understand SCL and multimedia-based pedagogies at a conceptual level as well as build their technological knowledge base through active construction of a multimedia presentation, leading them to implement TEL lessons within their instructional practice. I expected that participants would not only gain deeper knowledge on TEL but would also develop more positive attitudes and a stronger sense of efficacy toward TEL.

Since the needs assessment study (Chapter Two) was conducted, the staff at CMC has developed a focus on project-based learning, inspired by the film *Most Likely to Succeed*, detailing the project-based learning that occurs at High Tech High, a charter school program in Southern California. A representative of High Tech High later came out to CMC and led the staff in training on the design protocols that teachers at High tech high use in planning their projects. Other than this limited training, however, the participants experienced no further formal PD specific to SCL instruction. The intervention sought to capitalize on this recent interest in project-based learning and provide a deeper understanding of student-centered pedagogies as well as methods for facilitating such practices through the use of technology.

Pretraining meetings. Teachers were introduced to the project in an initial 30-minute session and were asked to sign a consent form. During a second 30-minute session, participants completed the TTF-TPACK and TPACK surveys and participated in a focus group interview during a final third 30-minute session.

Instructional stage. The first stage of the PD program (Appendix P) introduced participants to the central concepts of SCL (i.e., collaboration, authentic tasks, and student reflection) through five different multimedia presentations that were between five and ten minutes long (see Appendix Q). Following each multimedia presentation, approximately ten minutes were given for participants to ask questions about the SCL principle that was the focus of the session before collectively using Mayer's (2009) CTML (i.e., the elements of coherence, contiguity, balance, and personalization; see infographic that was used in Appendix Q) as a framework for reflecting upon and critiquing the multimedia presentation for about ten minutes. Table 4.6 details the topics and multimedia modalities that were presented in these sessions.

Table 4.6

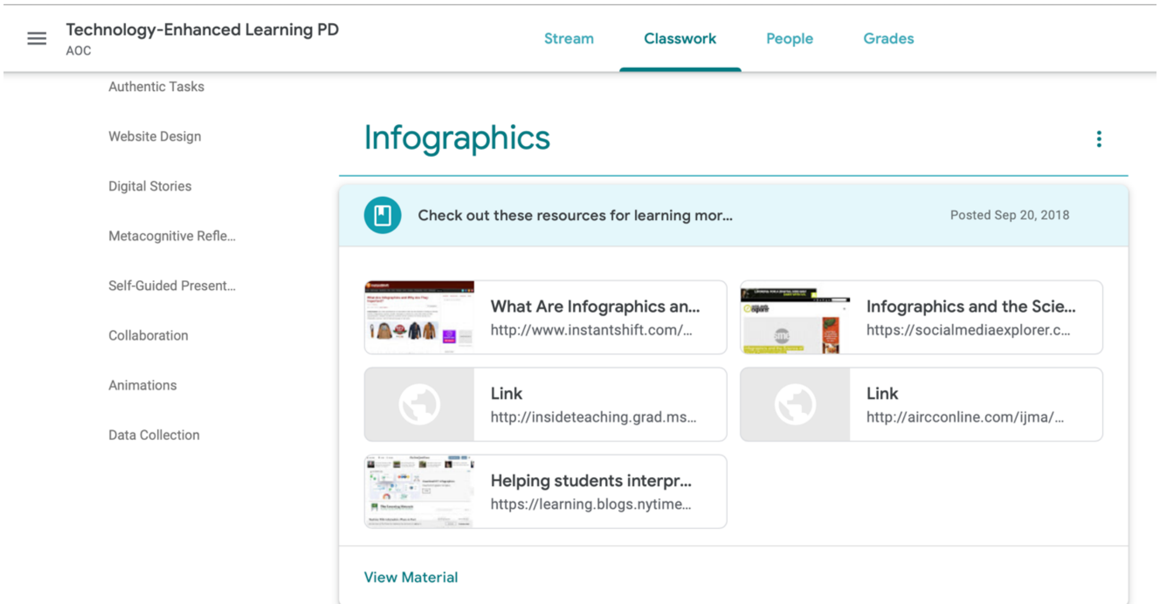
Instructional Topics & Modalities

Session	SCL Element	Modality
1	Overview of SCL Elements	Infographic
	Framework for Multimedia Learning	Infographic
2	Collaboration	Digital Animations
3	Critical & Creative Thinking	Website
4	Personalization of Learning	Digital Animation
5	Student Reflection	Self-Guided Presentation

Introducing each element of SCL through a different multimedia modality allowed participants to engage in a guided exploration of multimedia technologies and build a deeper conceptual understanding of how to use technology effectively (Mayer, 2014). Each presentation also built upon previous presentations in an effort to tap into participants' existing knowledge and build a stronger knowledge based related to SCL practices (Hmelo-Silver et al., 2007) while encouraging collaborative exploration of the topics that supports their learning (Bransford et al., 2000) as well as modeling effective TEL practices (McKenny et al., 2015). Finally, collective evaluation of the multimedia presentations helped participants develop a deeper conceptual understanding of the presentation medium, including its inherent strengths and weaknesses (Kearney et al., 2012).

These five training sessions took place during designated PD time built into the school calendar on Friday mornings. At the request of the school principal, the original 45-minute sessions were condensed to 30-minute sessions to allow for other school business such as discussion of student concerns. A GoogleClassroom site, an online learning management system (LMS), was also created to share additional materials and multimedia tools to encourage participants to extend their learning. A screenshot of the Classroom site is shown in figure 4.1.

Figure 4.1 Screenshot from Google Classroom Site Used for Intervention Trainings



Application stage. During the second stage of the PD program, participants applied their learning from the first stage to create a digital presentation. Following the principles of SCL, participants created a presentation on content for a current class (e.g., an authentic task). Similarly, they were allowed to choose the modality of the presentation and were encouraged to collaborate with their colleagues on a product that was cross-curricular in nature or vertically aligned within a discipline. Following the instructional design principles guiding this program (McKenney et al., 2009), participants constructed this presentation over three sessions, with a session each dedicated to brainstorming, storyboarding, and getting peer feedback on their storyboards (Appendix P).

Post sessions. Following each stage of the program, participants evaluated their experience in the PD program by completing an online exit survey. Following the application stage, participants also completed the TTF-TPACK and TPACK surveys and participate in a focus group interview during a 45-munite session.

Data collection

Quantitative and qualitative data were collected simultaneously in line with the convergent mixed-methods design. The following sections discuss the data collection process for each measure.

Process evaluation. I collected data related to the evaluation of participant perceptions, experiences, and involvement in the proposed program from three sources: field notes maintained in a reflective research journal as well as exit surveys and focus group interviews given at the start, midpoint, and conclusion of the program.

Field notes. Field notes systematically capture both the observed experiences of participants as well as the reflections of the researcher regarding the events and individuals they observe, providing a reflective process that can help guide research and identify areas of improvement in PD programs (Emerson, Fretz, & Shaw, 2011; Tracy, 2010). The primary instrument I used for collecting field notes was a reflective research journal, which included the notes recorded during the observation, a description of everything that could be remembered about the occasion of the observation, and my reflections on these observations. These reflections allowed me to analyze both my thoughts about what I observed as well as the act of observing the phenomena, giving me deeper insight into the event (Clough & Nutbrown, 2007; Borg, 2001; Ortlipp, 2008). Field notes were entered as soon as possible following each training session or observation.

Exit surveys. I collected exit surveys (Appendix K) from each participant at the conclusion of both stages of the intervention through Qualtrics, an online data collection program designed for administering surveys. A separate password was created for each survey and was provided to participants at the time the survey was taken to ensure data security. Ten minutes were provided during the final F2F session in each stage for the completion of these surveys and additional time was provided for participants to complete the survey on their own if they needed additional time. All participants submitted their responses within five hours, and the surveys were promptly closed after each the last participant submitted a response.

Focus group interviews. I conducted focus group interviews (Appendix L) at the start and conclusion of the PD program. The interviews were semi-structured and were recorded using an audio-recoding application on my smartphone, called RecordrHD. I took written notes during the interview and had the audio recording transcribed following each interview using TranscribeMe.com.

Outcome evaluation. In addition to focus group interviews, I collected data related to teacher knowledge, beliefs, and attitudes through two surveys, the TTF-TPACK survey (Appendix M) and TPACK survey (Appendix N) as well as through classroom observations of case study participants, including post observation debrief interviews.

TTF-TPACK and TPACK surveys. I administered both the TTF-TPACK and TPACK surveys online through Qualtrics. Both surveys were password protected. Participants completed the initial surveys in a F2F meeting prior to the start of the PD trainings while the poststudy application was completed on participant's own time during the week of the final training session, owing to time constraints.

Classroom observation field notes. I conducted classroom observations with the four case study participants at three points throughout the program: during the first month of the training sessions, in the final three weeks of the training sessions, and approximately two months after the intervention was concluded. Each observation lasted one instructional block, approximately 90 minutes. I collected written notes using the Technology Observation Checklist (Appendix O) and had transcripts of participant statements during the observation made from audio recordings using TranscribeMe.com immediately following the observation. Following each observation, I held a debrief session with the participant lasting between 20 and 30 minutes. I made audio recording of both the observation and debrief interview using RecorderHD. Stimulated recall (Nespor, 1985) was used to guide participants back through the observed lesson and promote a deeper reflection on the observed events from the participants' perspectives, including their perceptions of the lesson and its objectives. Following the debrief meeting, I had a transcript of the recording made using TranscribeMe.com and added to the transcript and notes from the observation for coding.

Data analysis

The final section, below, details the data analysis to evaluate the process and outcomes of this study.

Quantitative data sources. I entered all quantitative results into SPSS software package (version 25). Owing to the limited sample and population sizes, a Wilcoxon signed-rank test, a non-parametric test that is effective with small sample sizes, was used to investigate pre and post differences on the TTF-TPACK survey and the responses on the experience and confidences scales from the TPACK survey. Descriptive statistics including frequencies, means, and standard deviations were also reported for all quantitative measures.

Qualitative data sources. Following transcription, I entered all qualitative data into Dedoose, an online qualitative data analysis system, to help organize the data by type and date. Descriptors were used within Dedoose to help organize the data and allow for excerpts to be organized and analyzed within different contexts to help elevate patterns that might not otherwise be visible. I created descriptors for each participant, including their ID number, years of experience, grade level, and discipline, as well as the stage in which data were collected (i.e., prestudy, poststudy, and observation). Each piece of data was tagged with the appropriate descriptors.

Steps were taken to minimize the potential for researcher bias while coding and analyzing qualitative data. As an initial step, I deidentified each source. I also gave each data source an ID number used Random.org to randomize the order in which the data were examined to guide the analysis process. In this way, data were reviewed without knowledge of whether the data came from pre or post application of an instrument.

Each source was read initially to gain an understanding of the landscape of the data and memos. Thematic codes (Braun & Clarke, 2006) related to SCL practices (i.e., collaboration, critical and creative thinking, authentic tasks, and personalization of learning), types of TPACK-related knowledge (i.e., PCK, TCK, TPCK, and TPACK), and attitudes or behaviors served as initial codes. As additional data were analyzed, new codes that emerged were used to reexamine the data from earlier data sources in an iterative process that built a deeper understanding of the qualitative data (Drummer et al., 2008). This process allowed both new codes to emerge and existing codes to be re-evaluated. For example, codes related to PCK evolved from initially identifying evidence of PCK, to categorizing the strength of the knowledge that was evident in an excerpt into one of three groups (i.e., weak, moderate, or strong) and ultimately to refining the categories to two groups (i.e., weak or strong). The final code book that emerged from and guided the coding process can be found in Appendix R. Throughout the process, reflections on the coding process were recorded in the research journal to create greater transparency in the coding and data analysis process as well as to support validity (Ortlipp, 2008). The results from this analysis are detailed in the next chapter.

Chapter Five

Findings and Discussion

The purpose of this study was to investigate the efficacy of an SCL and multimedia-based teacher PD program to support teacher knowledge and beliefs toward TEL instruction. This chapter includes a description of the process for implementing both stages of the intervention as well as evaluations of the process and the outcomes of the intervention.

Process of Implementation

Ten teachers at CMC agreed to participate in the study, including all members of the mathematics, science, and English departments. Only one member of the social studies department participated. Two of the English teachers did not complete the second stage of the intervention (i.e., they did not create a multimedia presentation). All other participants completed both stages of the intervention. The process of implementing the intervention is described below along with an analysis of fidelity of implementation.

The first stage of the intervention involved instruction on the core elements of SCL instruction through a series of five multimedia presentations. Following each presentation, participants were given time to discuss what they saw, ask clarifying questions, and evaluate the presentation using Mayer's (2009) CTML model as a guide. The original plan called for these presentations to be delivered in 45-minute sessions using scheduled PD time on Friday mornings. As part of this plan, participant recruitment and prestudy surveys and focus group interviews were to occur during inservice training days prior to students arriving on campus. Entries from the research journal, however, documented two modifications to this plan. Owing to an extended process for receiving IRB approval, recruitment and prestudy data collection occurred on two separate Friday morning PD sessions approximately a month after the start of the school year.

Further, at the request of the principal, the individual lessons were condensed by 15-minutes allowing two presentations to be given and evaluated during each instructional session.

Following the delivery of the multimedia presentations, the design of the intervention called for three sessions to support participants in creating their own multimedia presentation. These sessions began in late October and were not modified. Eight of the ten participants completed a multimedia presentation.

Process Evaluation (RQ1)

A process evaluation was conducted to assess the fidelity to which the program was implemented using four criteria previously identified by Dusenbury et al. (2003): program adherence, dosage, quality of instruction, and participant responses. This evaluation was based on data collected from research journal entries as well as the exit surveys that were given at the conclusion of each stage of the intervention.

Program adherence was defined as the delivery of five multimedia presentations addressing different elements of SCL instruction, collective discussion and evaluation of those presentations using Mayer's (2009) CTML model, and participant creation of a multimedia presentation, either individually or collaboratively. Though the schedule of the instructional presentations was modified, all five presentations were given. Participants were also given time to evaluate the presentations using Mayer's (2009) CTML following each presentation. Finally, eight of the 10 participants were able to complete and deliver a multimedia presentation of their own.

Data from exit surveys, completed after the first and second stages of the intervention, were used to assess the dosage for this study (i.e., the amount of time participants engaged in the program). During the instructional stage, one participant reported not attending the session in which the third and fourth presentations were given and evaluated. All of the other multimedia presentations had full participation. Of the sessions set aside for the development of the multimedia presentations, a session in which participants presented the design of their presentation for feedback had three missing participants. One of those participants was working with two other participants on a presentation and was able to receive feedback on their presentation from their colleagues. The other two participants were working on a presentation together and did not complete that presentation by the end of the study. Five of the participants additionally reported seeking individual support from me outside the training sessions as they worked to complete their presentation.

Feedback from the exit surveys was used to assess participant perceptions of the effectiveness of the instructor who delivered the program content during both stages of the intervention. Participants reported a high quality of instruction on both applications of the survey, with a $M = 4.7$ ($SD = 0.38$) on the first exit survey and a $M = 5.0$ ($SD = 0$) on the second exit survey. These quantitative results were supported by remarks from participants on both exit surveys. For instance, on the first exit survey one participant remarked “I think the presenter did a good job of sharing about these new technology tools and guidelines to help in their development.” Similarly, on the second exit survey, one participant commented “I really appreciated the facilitator. He was kind and sympathetic to my busy schedule as was seen in his care for us as teachers.” One participant, however, commented on the second exit survey that “while I recognize that the study is of great importance to the facilitator, I feel that there is not adequate recognition of the fact that our role as teacher has to take precedence over this study/project.” This was the only critical statement on the exit survey responses, but it suggests that although most of the participants perceived the quality of instruction as strong at least one participant did not feel that they received enough support and consideration throughout the intervention.

The extent that participants were engaged in and found value in the activities and content of the program was assessed from both the exit surveys as well as entries in the research journal. The exit survey results, noted in Table 5.1, suggest that participants were moderately engaged in and found value from both stages of the intervention. With a mean of 4.8 (*SD* = 0.42), participants reported the strongest agreement with the statement "the training was relevant to my instructional practice" on both applications of the survey. On the first exit survey, participants reported the lowest agreement (*M* = 4.5, *SD* = 0.52) with the statement "the training was engaging," while on the second exit survey the lowest agreement (*M* = 4.6, *SD* = 0.41) was related to the statements "the training provided valuable information" and "the training can be easily integrated into my instructional practice."

Table 5.1
Results from Exit Surveys Related to Participant Perceptions of the Training (n = 10)

Prompt	Exit Survey 1 M (SD)	Exit Survey 2 M (SD)
The training provided valuable information	4.70 (0.48)	4.60 (0.41)
The training was engaging	4.50 (0.52)	4.70 (0.48)
The training was relevant to my instructional practice	4.80 (0.42)	4.80 (0.42)
The training can be easily integrated into my instructional practice	4.80 (0.42)	4.60 (0.51)

The written feedback provided on both exit surveys also conveyed relative satisfaction with their participation in the intervention. On the first survey, for example, one participant noted how "it was helpful to see multiple examples of media that I can use to both present information to my students and to have my students use for presentations." At the same time, another participant noted that:

> The content was interesting and relevant but brought up new questions that were unable to quickly be answered in the time allotted. Also, my ability to focus and remain engaged was problematic for me, especially since much of the content was thought provoking, and I needed more time to process all the material.

This suggests that although this participant found that instruction valuable, they also felt overwhelmed by the amount of information being provided. The research journal entries from the first few training sessions also noted a consistent concern by teachers that they were overcommitted and felt that the shift to TEL instruction required too much time.

In a similar manner, the written responses on the second exit survey suggest that participants found value in the intervention. One participant, for instance, reported how the "multimedia design criteria—coherence, contiguity, balance, & personalization—was the most useful" while another participant exclaimed:

> Overall, I feel that this experience has been one of the most practical, salient, and applicable forms of professional development I have received in my career. Real-time, research-based practices being shown followed by the creation of a relevant, ready-to-employ product...this should serve as a template for effective PD instruction.

At the same time, the research journal noted consistent concerns that participant's time was too constrained by grading and lesson planning to focus on the multimedia presentation they were creating. Two participants, in fact, felt so overwhelmed that they did not come to the final two sessions dedicated to creating the multimedia presentation and did not produce a finished product at the end.

Summary. The evidence presented here suggests that the intervention was implemented with fidelity. The program design was adhered to, though the amount of time dedicated to each multimedia presentation was adjusted due to time constraints. Most participants also reported attending all of the training sessions and those who were not able to attend a particular session were able to access the full presentation as well as additional support material through the GoogleClassroom that was created for the intervention and seek out additional support and guidance from me. Furthermore, most participants reported feeling that instruction they received was of high quality and the training they received was valuable. A few participants, however, reported having concerns about the amount of information that was covered as well as the time they had to commit to creating a multimedia presentation during the second stage. These concerns are consistent with participant reservations in prior studies on teacher cognition (Merinink et al., 2009; Mouza, 2009) as well as the design of TEL environments (Lesseig, 2016; McKenney et al., 2015).

Outcome Evaluation

An outcome evaluation was conducted using the TTF-TPACK survey (Jamieson-Proctor et al., 2013), a TPACK Survey created for this study, focus group interviews, and classroom observations to evaluate short- and long-term outcomes as identified in the theory of change model (Appendix I). Short-term outcomes hypothesized in this study included changes in participants' PCK, TCK, TPK, and TPACK as well as improved perceptions of and self-efficacy toward TEL instruction. The long-term outcome identified was the implementation of TEL practices in participant's classes. All data sources were reviewed individually and collectively in an iterative process to help identify specific patterns related to teacher knowledge and beliefs.

Most participants reported changes in their knowledge and beliefs at the conclusion of the study. These differences were most prevalent amongst the mathematics, social studies, and English participants. The science teachers who participated noted few changes throughout the study, consistently reporting strong knowledge and beliefs. Meanwhile, two of the English teachers reported no significant changes in their knowledge and beliefs. Finally, evidence from case study participants suggests that few TEL practices were implemented within participants' classes that were not already in place as a result of prior experience or PD. In order to explore the various patterns and identify cogent changes within and between disciplines, the experiences of case study participants are detailed first before combining their experiences with other data sets to fully investigate each research question.

Case Studies

Data from case study participants were collected from the pre- and poststudy surveys and focus group interviews as well as from classroom observations and post observation debrief interviews. Following the coding of the qualitative sources, the data were collected to create a narrative of the experience of each case study participants. Each narrative is explored in detail below.

Eric. Eric was a mathematics teacher at CMC and was an active participant in all lessons and data collection throughout the study. By the end of the study, he reported differences in his knowledge and beliefs toward TEL, particularly new understandings in his PCK and TCK. He also reported perceiving fewer barriers to integrating TEL practices into his instruction. Observations in his classes, however, suggest that these changes did not yet lead him to substantially alter his pedagogical practices.

Changes in knowledge. Eric reported a different understanding relative to his PCK, TCK, and TPACK, but not his TPK, between the start and conclusion of the study. With regards to PCK, his responses on the initial TPACK Survey emphasized elements of direct instruction. For example, in discussing strategies to support student learning he reported the "need to incorporate more direct instruction and modeling than in classes utilizing applied knowledge." In contrast, in response to the same question on the poststudy survey, he responded by saying "the more the merrier in mathematics, especially when teaching skills-based classes like Algebra 1 and Geometry." In the poststudy focus group interview he added:

> the formulas are basic. So, if they understand what's happening and what they're looking for, then they should be able to apply the numbers to it… that seems to have been a hiccup over the years of only looking at drawings on a piece of paper.

Correspondingly, in the prestudy surveys and interviews, Eric was skeptical of the value of using multimedia technologies to represent mathematical concepts. He also emphasized the use of calculators for student practice and the Notability app on his iPad as a tool for delivering content. In his word, "well, usually, something's awesome for math and nothing else or is awesome for everything but math." This suggests that he saw multimedia technology as well suited for other disciplines, but not as much within mathematics, as well as some uncertainty in how content in mathematics could be presented through multimedia technologies. At the conclusion of the study, however, he talked more extensively about multimedia tools that he saw as useful in his classes. For example, he discussed using infographics in his classes, noting that "I think that one of the benefits to incorporating digital technologies to mathematics is the ability to create visual representations of content." These reflections point to a new awareness of the potential for using multimedia tools in delivering content in mathematics (Harris et al., 2009; Koehler & Mishra, 2009), evidence of changes in his TCK.

In contrast to his reported growth in PCK and TCK, Eric did not evidence a significant increase or decrease in his understanding of how to use multimedia technologies to implement instruction within mathematics. Both before and after the intervention, he emphasized using the Notability application on his iPad so that "pretty much I can take a digital pdf, write over it, I can save that if I wanted, I can delete it, I can move stuff around and not affect the original document" as well as the application BookWidgets where "I was able to grade the 33 tests in seven minutes." These statements suggest that throughout the study he maintained an understanding of technology as a tool to demonstrate how to solve problems, facilitate grading and communication with students, and provide students with review materials.

Finally, evidence from classroom observations suggests that Eric identified slight changes to his understanding of how SCL practices and multimedia technologies could be combined to support student learning in mathematics (i.e., TPACK). Whereas in the initial observation he emphasized a limited number of digital tools to facilitate guided review of material, the poststudy observation lesson involved students collaborating to identify examples of different prisms in the world (i.e., Mount Whitney as an example of a triangular prism) for which they then found the measurements, calculated the surface area, and built a multimedia presentation to share their findings with the class. Although this project asked students to apply their textbook learning to real-world examples, it did not ask students to engage in the critical and creative problem solving that is a hallmark of authentic tasks. During the debrief interview following this lesson, however, Eric further noted how this project is one that he had implemented with previous classes but now was modified to include greater collaboration and the requirement to use a multimedia tool to present findings. The implementation of this project seemed, therefore, to evince in Eric some new understanding of how to design activities that integrate multimedia technologies and collaboration to promoted student understanding of mathematics. This new understanding, however, seemed to fall short of the meaningful changes in TPACK that were hypothesized in the causal model guiding the intervention (Appendix I).

Changes in beliefs. In addition to new knowledge of TEL practices, Eric reported differences in how he perceived TEL instruction as well as his ability to integrate TEL practices into his classroom. Prior to the intervention, Eric noted a number of barriers to TEL within mathematics, including limitations imposed by the curriculum, concerns about student engagement, and inherent student limitations that would make TEL incompatible with learning in mathematics. During the prestudy focus group interview, for instance, he reported that "in algebra and geometry there are so basic skills based [sic] that if we did a project it'd be really hard for everyone's project not to be the same" and then emphasized how mathematics teachers need to constantly "reteach something we did, something the people before us did or didn't do or did a different way." Therefore technology, as he noted in the TPACK survey, was useful in that it can support "a higher quantity of practice and problem presentation and completion for subjects that normally are time consuming." Later, during the debrief interview following the first classroom observation, when asked about integrating technology to support SCL practices, he noted that student "feedback when I did it the first time here is that they didn't like it so much. They would have rather just move on." He also suggested that his students had limited ability to engage in TEL by commenting "they're not as proficient necessarily. They're not as used to doing it."

These statements point to a general perception that mathematics requires an emphasis on directed instruction, that technology is useful when it supports teacher-directed pedagogies, and that students themselves are a barrier to integrating TEL practices. Khattri and Miles (1995) noted how such barriers are often facilitated by traditional views of education held by teachers and that the incorporation of SCL practices often challenges these views, encouraging deeper resistance to such integration. Ashton and Web (1986), however, note that teachers with a low sense of efficacy toward new instructional practices may emphasize student limitations as a way to explain how or why such practices failed within their context. It is thus possible that the emphasis Eric placed on the limitations of their students, at the start of the study, is evidence of his lack of self-efficacy toward TEL practices.

At the conclusion of the study, Eric reported a shift in both his perceptions of TEL as well as of his ability to facilitate such instruction. He still reported a notable concern about the nature of mathematics curriculum when incorporating TEL practices, stating “the only thing that seems to work, overall, for everyone is multiple bouts of practice [sic] fixing it and things eventually clicking.” This emphasis on repetition to support learning in mathematics, however, was the only specific barrier that he reported in the poststudy data. His attention, instead, shifted toward the affordances that TEL practices provided when it came to student engagement and application of knowledge. He reported, for example, that students were more engaged in a project where they applied their understanding of three-dimensional prisms to real-world examples than when they were solving problems from their textbook. He also emphasized the importance of student collaboration by noting “students talk to other students, and sometimes, it's just, I think, hearing it like zone of proximal development.… They're talking to other students and helping them out instead of me running to everyone.” Finally, despite not demonstrating application of authentic tasks within his lessons, he noted how such tasks “could be a great tool to get students to think about how to use the knowledge they have to solve the problem.”

The evidence presented here suggests a newfound appreciation for TEL practices that may have replaced some of the barriers Eric perceived prior to participating in the intervention. They also suggest Eric felt more confident in his ability to use multimedia technology to guide student learning and to engage students in SCL practices. In his words, “my experience went through the roof!”

Implementing TEL. Despite the differences in knowledge and beliefs that Eric reported, observations in his classroom revealed few modifications to his instructional practices between the start of the study and the final observation over a month after the study concluded. The first two lessons observed in Eric’s class were predominantly based on question and answer sessions designed to check student understanding of existing knowledge. In the first lesson, he used an application called Notability to project a pdf version of the worksheet from his iPad so that he could review problems from the geometry textbook calling on different students to help solve part of a problem. The primary purpose of the lesson, as he defined in the debrief interview following the observation, was to review for an upcoming quiz. Similarly, during the second lesson observed, he used an online application called BookWidgets to review a recent quiz, provide an opportunity for students to practice a few problems, and then repeat the same quiz that had been previously given. In both cases, digital tools were used as a substitute for more established lecture tools (i.e., chalkboard, whiteboard, or overhead projector) rather than to provide a medium for students to apply concepts they learned to solve authentic problems.

The final observation in Eric’s class evinced some practices more consistent with TEL, such as collaboration and student use of multimedia technology to present findings, but did not ask students to engage in an authentic task. Although he started the lesson as he had in the previous two lessons, by reviewing questions in their textbook using the Notabilty application on his iPad and answering student questions, during the second half of the period he introduced the project in which students identified and reported on real-world examples of prisms, reported above.

Although this project included student collaboration, extended student learning beyond the textbook work in a manner not previously observed in his class, and asked students to work with multimedia technology to present their findings, the task itself did not engage students in the critical or creative problem solving that exemplifies authentic tasks (Grant & Branch, 2005). Further, during the debrief interview following this observation Eric noted that he had assigned this project in a small form the previous year, without student collaboration, the multimedia presentation, and requiring students to only find two real-world examples of prisms. In a discussion about additional projects that he was thinking of integrating, he hesitantly noted that he might try another project toward the end of the year but emphasized the need for students to engage in constant practice with problems from their textbook. This suggests that while Eric was inspired to incorporate new multimedia technologies into this lesson, he saw his curriculum as an impediment to enacting the new knowledge and beliefs about TEL from the intervention in his pedagogical practices.

Vanessa. Vanessa was a chemistry teacher at the time of the intervention. Despite consistently reporting strong knowledge of and positive attitudes toward TEL practices, she still reported new understanding related to TPK and TPACK as well as greater confidence in her ability to implement TEL practices within her classroom, especially with regard to SCL practices. Evidence from observations in her chemistry classes also identified differences in the amount of TEL practices that were integrated between the first and final observations, though Vanessa reported that these changes were inspired by a recent PD from an outside agency rather than from the intervention within the current study.

Changes in knowledge. Vanessa reported no meaningful change in her PCK or TCK between the start and conclusion of the study. This lack of deviation was largely a result of holding a clear understanding of both SCL pedagogies as well as how to use digital tools to deliver science content at the start of the study. She consistently emphasized project-based pedagogies that included collaboration, authentic tasks, and opportunities for reflection. As an illustration, on the prestudy TPACK survey she identified “hands-on lab activities, research-based projects, class discussions and viewing phenomenon through videos or demonstrations” as best instructional practices and then noted in the focus group interview:

> for me, for science, it's real-world experiences. So, [sic] lab activities so they understand abstract topics and then diving into mass amounts of data and graphing it through different technological programs and then writing about it through the claim evidence reasoning [model].

These statements emphasize a strong understanding of SCL practices that were consistently validated during the observations in her classroom, as students worked in teams to disaggregate data related to climate change, investigated ways to address ocean acidification, and build dynamic presentations to present their findings to the school community.

In a similar manner, she demonstrated advanced understanding of graphic design applications, self-guided presentations, and infographics and how to use these tools to present information throughout the intervention. She discussed, for instance, her experience creating infographics and using digital tools such as GeoGebra and the Common Online Data Analysis

Platform in her classes during the initial classroom observation debrief interview. These sentiments suggest a consistent and strong familiarity with different multimedia technologies and the ability, even eagerness, to seek out new technologies and use those tools for presenting science content, which are all indicators of strong TCK (Mishra & Koehler, 2006).

Although she did not report any meaningful difference in her PCK and TCK, Vanessa did report new understanding related to her TPK and TPACK at the conclusion of the study, despite evincing a deep understanding of both types of knowledge at the start. With regard to TPK, in the prestudy focus group interview she reported how she used GoogleClassroom to facilitate activities that asked students to collaborate and evaluate charts and graphs and report results using an infographic. This suggests a strong understanding of how to use multimedia tools to facilitate student learning. In the poststudy interview, however, she discussed in greater detail the limitations that students encounter when working with digital tools, such as animations. This suggests a deeper knowledge of student needs in using technology as well as her ability to adjust her practices to account for those limitations. Further, it suggests a more concrete understanding of how to design lessons that require students to use technology in innovative ways that builds both their CK as well as their understanding of how to use technology in an effective way.

In a similar fashion, Vanessa reported a clear understanding of how to combine multimedia technologies and SCL practices to drive instruction, evidence of TPACK, throughout the study. In the prestudy focus group interview, for example, she discussed how she was engaging her classes this year in a deeper understanding of how to visually depict research within chemistry. In her words:

> graphing is just a really big thing. CODAP has a really cool data-diving thing where you can create infographics with the data that they have. They have massive amounts of data,

> and it allows kids to amass the data and make graphs depending [pause] they can create their axes and just put different categories there, and just play with it instead using the one piece of data they may get from the lab.

This description displays a sophisticated understanding of how to leverage technology to address a pedagogical concern as well as an authentic concern amongst scientists (i.e., how to better present scientific findings so that non-scientists can understand them).

During a poststudy observation in her class, Vanessa demonstrated even stronger TPACK as she supported students while they were engaged in a digital storytelling project. This project engaged students in collaborative research into to one of several problems connected to climate change (i.e., one group was looking at the amount of plastic in the ocean, another was examining enzyme reactions) and displaying the results of their research using an online graphic program. This activity demonstrated an advanced understanding of how to engage students in multimedia-based, student-centered practices that would help them understand more deeply complex chemistry content chemistry.

Changes in beliefs. In addition to reporting strong knowledge of how to use multimedia tools and SCL practices to drive instruction, Vanessa consistently identified strong affordances related to TEL instruction in her classes throughout the study. In particular, she noted how TEL tasks created affordance for learning through real-world tasks and increased student engagement. In the prestudy focus group interview, for instance, she stated that “for me, for science, it's real-world experiences.” Following the intervention, she similarly discussed how TEL tasks mirror projects professional in which scientists engage, noting that “what Harvard and all of these people are showing DNA and how proteins work and gene editing and slicing and dicing and all of these. This is the new kind of way to show it." These statements emphasize a consistent affordance from TEL through the real-world application of learning it provides.

In a similar manner, Vanessa also consistently reported how the incorporation of technology and SCL practices helped to create stronger engagement in the learning process. In the prestudy TPACK survey, she stated that "students are more engaged with lessons that are tech savvy." In the poststudy data, she likewise remarked on how TEL practices encourage student ownership in the learning process. In her words, "we gave them so much control and it makes us vulnerable to having things go awry and they respected that level of openness that we gave them and kind of built a more trusting bond." These statements suggest that she held positive perceptions of TEL practices, with regards to student learning, prior to the start of the intervention and that she maintained these positive perceptions throughout the study.

Despite maintaining a positive perception of the value of TEL tasks, Vanessa did report a change in her level of comfort toward TEL instruction, particularly with regard to integrating SCL practices. Although she consistently reported confidence in her ability to find and use technology, in the early classroom observations she was hesitant about in her ability to facilitate SCL practices in her classes. During an initial classroom observation, she was visibly frustrated when trying to support groups of students who were working on a project using data related to climate change. At one point, away from students, she even commented to me "I am just not sure how to do this." Later, during a debrief of the observation, she voiced similar frustration about guiding students in collaborative settings. The conversation proceeded as follows:

Interviewer: Do you feel like that strengthens the activity?

Vanessa: I'm not sure. This is kind of a new thing that I started with last year, and I'm not sure how to make it more targeted… I don't know how to target on the actual task.

During the final observation in her class, on the other hand, she displayed a greater sense of confidence as she guided students in a project. As noted in the hand-written notes from that observation the "teacher demonstrated complete comfort in students working on a digital storytelling project where she acted as a guide-on-the-side rather than providing direct instruction." In the post observation debrief interview, I asked how she felt about guiding students through such projects rather than lecturing or other forms of directed instruction. She replied:

> I like it. Obviously, it's much easier to do straightforward [pause] this is how to read a periodic table. This is how to balance an equation. It's easier to do that kind of teaching. This is much more complicated in the fact that you're guiding them in different directions and herding them…. But this is more exciting.

These statements suggest a confidence in guiding instruction through SCL practices that was not as readily visible in the prestudy data.

TEL Integration. The lessons observed in Vanessa's classroom demonstrated different technology-based instructional practices between the first lesson and the final lesson. Evidence from interviews with Vanessa suggest, however, that these modifications were part of an intentional design that included more directed tasks in early lessons to support student skills development leading to more student-centered and technology-rich tasks. Further, this design was inspired by a recent PD experience that Vanessa participated in outside CMC and not a result of the intervention from the current study.

The first lesson in Vanessa's class was mostly teacher directed with about half of the lesson focused on reviewing material in preparation for a quiz, which was given after the review session. Following the quiz, she gave a slideshow presentation with different graphs related to ocean acidification where she asked students to analyze the message design of the graphs. Her goal, as she noted in the debrief interview, was to instruct students on the best ways to use visual images to depict scientific data. Although the questions that she asked (i.e., color scheme, alignment of texts with images, and amount of information presented) modeled effective multimedia message design (Bishop, 2014), the lesson did not ask students to use the technology themselves.

At the conclusion of the first observed lesson, however, Vanessa referred to an upcoming project where students would be using technology in more substantial ways. This project was evident in the second classroom observation, at the conclusion of the intervention. In this lesson she led students through an activity on color schemes that was part of a series she had entitled Design for Non-Designers. Students watched a video on color theory and used different colored pencils to explore the various concepts addressed in the video. Vanessa stopped the video after each segment to ask students questions to assess their understanding of what they were viewing, ask them to think more deeply about the principle being discussed in the video, and reminded students to use their colored pencils. Following the activity on color theory, students were directed to work in preidentified groups on creating a digital story project to explain data related to a chemical process, of their choice, relevant to climate change. During the workshop, Vanessa walked around the room, answering questions and providing guidance, while taking notes on student/groups progress. Throughout this process, Vanessa acted as a guide-on-the-side and supported students as they collaborated on an authentic task where they used multimedia technology, in this case an infographic, to present their findings.

Similarly, students were engaged in a collaborative effort to research a chemical reaction in nuclear medicine and explain their findings through a digital animation, during the final classroom observation in Vanessa's class. The lesson started with a review session on stoichiometry, during which Vanessa reviewed a worksheet. Students were given a copy of the worksheet and the worksheet was projected on the screen using the document camera. Students were then directed to work on a nuclear medical presentation project they had previously started. This project asked students to develop an animation to explain the chemical reactions central to an element of nuclear medicine. Groups were allowed to choose the type of animation they wanted to use, including using Google Slides, and the teacher provided step-by-step directions on how to create an animation with this tool. Vanessa set a two-minute maximum on the animation so that the students could use free versions of online animation creators such as PowToons. While students were working, she again walked around the room, providing suggestions and asking guiding questions, including questions about multimedia design that were specified within the intervention.

Though the collaborative projects on ocean acidification and nuclear medicine incorporated elements of collaboration and authentic tasks that are evidence of TEL-integration, during the debrief of the final observation Vanessa indicated that the design of these projects was inspired by a recent PD program she had been involved with at the Aquarium of the Pacific and not the intervention that was part of the current study.

Richard. Richard was the only social studies teacher to participate in this study. Throughout the course of the study he reported new understanding related to TCK and TPK. He also noted fewer barriers to incorporating TEL practices. These changes were particularly evident in his ability to speak more fully about his understanding of the pedagogical practices that align with TEL as well as his perceptions of the usefulness of incorporating TEL practices into his instruction. Classroom observations also document how Richard's lessons incorporated more multimedia technology to support SCL practices.

Changes in knowledge. Richard reported new awareness in all forms of knowledge, especially TCK and TPK, by the conclusion of the study. The strongest evidence for this difference came from his ability to speak in stronger terms and at greater length about his practices at the conclusion of the study in comparison to his responses in the prestudy data. For example, he responded to a question on the TPACK survey about best instructional practices for teaching social studies by noting "group discussion, individual and group research assignments" and did not elaborate upon this point when given the opportunity in the focus group interview. At the conclusion of the study, on the other hand, he responded to the same survey item with "group discussion, group work, project-based learning, inquiry based. They offer a chance for students to be inquisitive, learn from each other, personalize the learning, and reflect and refine work." He then elaborated on the value of SCL practices during the debrief interview following the final observation in his classroom by noting how, in a student-centered project on totalitarianism, students were "covering each other's base on anything that they're talking about…. As a group, they're to work together on kind of piecing what the themes are that they're seeing." These comments display a greater ability to speak expansively about his pedagogical practice while emphasizing elements of SCL practice that were not expressed prior to the intervention. Such evidence suggests that Richards PCK was stronger at the end of the study than it had been at the start.

Richard's data also reflected a different understanding of how to use multimedia technology to deliver content and facilitate SCL practices within his classroom between the start and conclusion of the study. In the debrief session following the first classroom observation, for instance, he discussed why he has not incorporated digital technology to guide the simulation on imperialism that he facilitated during the lesson. In his words “I never thought of it. I don’t think it would work.” This suggest that he didn’t see ways that multimedia technology could be used to represent the content from this lesson in new or different ways. During the poststudy focus group interview, on the other hand, he demonstrated a smartphone application for using augmented reality to allow students to explore different multimedia content placed digitally around the room and, in his words, “experience my class in a new way.” He further elaborated on how this technology could provide students with new ways to present their research and digital projects to each other as well as to other members of the CMC community. This suggests that Richard, at the end of the study, saw application for multimedia technology to communicate information and findings (i.e., TCK) that had not been present at the start of the study.

Similarly, his discussion about digital technology to support student learning on the prestudy TPACK survey focused on how students could access the college library databases for research, how “shared documents among colleagues has allowed a broader and more detailed understanding of each student and their individual needs,” and how “using Google Sites, students can practice and develop foundational and stylistic skills of writing.” These statements emphasize digital technology as a tool for sharing resources, facilitating grading, and for developing student foundational skills without identifying the pedagogical affordances or barriers in using multimedia technology, such as GoogleSites, to direct instruction. In the poststudy TPACK survey and focus group interview, however, he repeatedly discussed leading a grade-level project to help students showcase their work digitally through a collaborative website, which would serve as a means of instructing underclassmen on how to effectively communicate their ideas through multiple multimedia formats, including animations and infographics. This indicates that, at the conclusion of the study, Richard saw different ways to apply multimedia technology to support student learning that was not evident at the start of the study.

In the final observation in his classroom, furthermore, Richard was able to demonstrate how he could use multimedia tools and SCL practices to foster student learning in social studies. This lesson centered on a collaborative project where groups of students would teach the class about a particular dictator from the 20th -century. The students identified whom to focused on and were allowed to select a digital presentation medium that they felt best allowed them to present the material, which are practices that align with SCL pedagogies (Daigle, 2000; Hmelo-Sliver et. al., 2007). Richard systematically reviewed the multimedia platform each group had chosen to use for their presentation, asking guiding questions designed to help them examine the strengths and weaknesses of that chosen medium for their specific presentation. In this way he not only demonstrated a deeper understanding of digital tools than he reported prior to the intervention but also a more sophisticated understanding of how to guide student learning through SCL practices using that technology as it related to social studies, evidence of deeper TCK, TPK, as well as TPACK (Mishra & Koehler, 2006).

Changes in beliefs. In addition to new knowledge of TEL practices, Richard also reported different perceptions toward TEL between the start and conclusion of the study. During the focus group interview conducted prior to the study, he reported being worried about the limitations of students who entered his classes, stating that “coming into sophomore year there is a struggle with group work. A lot of them come in with anxiety.” He also noted that these limitations made projects difficult to coordinate and implement. When asked why technology was not used to drive a simulation-based lesson in the initial classroom observation, for example, he reported “I never thought about using technology that way.” Later, when asked why he didn’t use digital technology within a class lesson, “I don’t think it would work.” Despite such concerns, however, he also reported a belief that TEL practices could facilitated student learning. He noted how such practices increased student engagement and that “you can tell they're just understanding like how to break apart their argument and then work with it.” He further noted that using technology within student-centered projects helps students to “develop skills that are applicable to other fields.” These statements suggest that, even before the study began, he held a positive view of SCL practices and saw such practices as facilitating student engagement and deepened the learning experience, though he worried about how student limitations impacted such learning and was uncertain about how technology could be used to facilitate learning within SCL practices.

In the poststudy surveys and interviews, Richard emphasized the affordances that TEL practices provide for student learning to an even greater extent than was reported in the prestudy surveys and classroom observations. For example, in a discussion about a TEL-based project he implemented in his class in which students used multimedia tools to design an engaging lesson for their peers, he noted how technology “allows students to work together to accomplish a common goal” and that engaging in such projects “offers a chance for students to be inquisitive, learn from each other, personalize the learning, and reflect and refine work.” In the poststudy focus group interview, he further stated that “one reason I like doing this is they have a different perspective on learning. Because being the one in charge, as I think as teachers we all get it, there's a different feel on it.” This suggests that, in addition to creating engagement and facilitating the critical thinking that is essential to learning within the social studies (National Council for the Social Studies, 2013), he saw the potential for TEL practices to give students greater ownership in the learning process. Finally, he spoke with great enthusiasm about the potential for using augmented reality as a tool for facilitating student learning in his classes and within cross-curricular projects. The enthusiasm he displayed for this potential was in contrast to prestudy reports about integrating TEL projects. Such a change suggests an improved sense of confidence in his ability to find and use new digital tools to facilitate student learning.

TEL integration. The lessons observed in Richard's class demonstrated a consistent focus on student collaboration and active engagement in lessons on major events in world history. Though the first lesson asked students to engage in an authentic task, the nature of the task in the second and final observations were increasingly more authentic and complex. Additionally, although the first two lessons did not ask students to engage with digital technology, the final lesson required students to use multimedia tools in a manner more consistent with TEL.

The first lesson observed in Richard's class incorporated involved a simulation to help students understand imperialism. Students worked in collaborative groups to complete reading quizzes. After completing a quiz, they would have Richard score it and, if it was fully accurate, they would be allowed to identify one territory on the map that they could conquer. These groups were organized with each student having a different role within the group, including a group leader. The teacher spent part of the time moving from group to group to answer questions and the remainder of the class at his desk where he scored quizzes and recorded the conquests that each group made using the overhead projector. At the conclusion of the lesson, there was a brief reflective activity.

The student collaboration as well as the reflective activity at the conclusion of the lesson were consistent with SCL, but the tasks that students were assigned did not require them to struggle with the complexity of a problem in order to develop a deeper understanding of the content as is often the case with authentic tasks (Bransford et al., 2000; Hmelo-Silver et al., 2007). During the debrief interview following the observation, Richard noted that the purpose of the activity was to allow students to minimize their workload by completing tasks together and to be able to visualize how European powers gained colonies across the world. As such, the task did not direct students to consider the consequences of imperialism or its impact on students' contemporary world, tasks that would have been more authentic in nature. Moreover, the lesson did not require or support students in using digital technology to engage with the task.

The second lesson observed in Richard's class also involved a simulation, this time of the Paris Peace Conference at the end of WWI. Within this simulation, students were broken into groups, asked to review preparation materials about the nation they represented, and then established goals for the treaty negotiation process that helped guide them through the simulation. Throughout the simulation, Richard intermittently moved between groups for several minutes before returning to his desk. At the conclusion of the lesson, students were asked to complete a digital reflection on their activities. As with the first observation, this lesson made use of student collaboration and reflection consistent with SCL practices while also integrating a task that is authentic to a world history class but also did not incorporate technology as a tool to guide student learning. During the debrief interview, in response to a question about how to integrate or drive this simulation through technology, Richard said that he had not thought of doing that before and that it was something he would have to think about but was not interested in integrating technology simply for the sake of using technology.

In contrast to the first two observations, the final lesson observed in Richard's class required students to use multimedia technology as part of their learning process. In this lesson, students were employed in creating an hour-long lesson on a dictator to present to their class. This collaborative project required students to consider how to engage their peers in learning about a dictator and the impact that this leader had on the government structure and people of their nation. They were further directed that at least one element of the presentation had to be through an interactive, multimedia activity. This requirement encouraged groups to explore different technologies they could use to create interactive activities. Finally, they had to develop a visual presentation that addressed several of the multimedia dimensions addressed in my intervention lessons. Throughout this process, Richard served as a guide-on-the-side, helping students to understand how to use the digital technologies in the room and asking them questions to get them to consider new ways to engage their peers. As such, students, in this lesson, were involved in active collaboration on an authentic task that was designed to engage them in deeper learning specific to their content area, using various multimedia tools that they selected to guide the construction of their knowledge. Like Eric, however, Richard noted in the post observation debrief interview that this lesson was one that he had used with prior classes and was not the result of his participation in the intervention.

Danielle. Danielle was one of the five English teachers who participated in the study. Between the start and conclusion of the study, she reported differences in her PCK, TCK, and TPK. Her statements also suggest that her beliefs toward TEL instruction changed as she noted greater affordances from and comfort with TEL practices at the conclusion of the study. Classroom observations, on the other hand, documented practices consistent with direct instruction in all three lessons. The altered knowledge and beliefs, therefore, did not seem to support TEL integration in Danielle’s class.

Changes in knowledge. Danielle demonstrated pre- and poststudy differences in her knowledge related to multimedia technologies and SCL practices. As an illustration, in the prestudy focus group interview she discussed the importance of repeated practice with annotations, noting “it’s the basis for any kind of presentation, writing assignment, whatever kind of formative or summative assessment” as well as the importance of peer review as a strategy. The emphasis on student practice of skills and peer or teacher feedback is consistent with teacher-directed instruction (Meijer et al., 2001; Verloop et al., 2001), although the emphasis on skills that she considers universal (i.e., not subject specific) points to a limited understanding relative to PCK at the start of the study (Shulman, 1987).

At the conclusion of the study, however, Danielle discussed a cross-curricular project with the 10th-grade history and science teachers in which students created “an internal, private website for student use for class resources and showcasing their learning. In building the website, they will learn skills in technology, design, collaboration, writing, editing, and critiquing.” She further spoke of the importance of students communicating ideas in a number of different mediums in order to be ready to compete in the 21st-century and detailed a number of different strategies for promoting student learning including modeling, small group work and discussions, Socratic seminars, and gallery walks. These statements demonstrate a greater ability to speak about strategies that support learning in English, which Shulman (1987) and van Driel et al. (1997) argue is evidence of PCK growth.

Danielle’s responses also reflect a different perspective of how to use different multimedia technologies to deliver content and facilitate learning. At the start of the study, for example, she stated that she used an iPad application called CamScans “so that I can collect stuff but they still have their hard copies. So, their annotations that I talked about earlier, I can look at those but they have their actual annotations to be working on their current assignments." Similarly, she emphasized how she used digital tools such as Kahoot.com, Nearpod.com, and Turnitin.com because "students need to get immediate feedback" on their writing. These statements suggest an understanding of digital technology as a tool limited to providing immediate feedback to correct student mistakes and share resources, a practice consistent with limited TPK (Meijer et al., 2001; Verloop et al., 2001).

In contrast, at the conclusion of the intervention, Danielle displayed a stronger sense of how to use multimedia tools, including infographics, videos, self-guided presentations, and animations, to present content and engage students in SCL practices within English. This was clear in a classroom observation at the end of the study during which she engaged students in an examination of literature from Edgar Allan Poe through podcasts and videos, while directing them to build a website as a final product for the unit rather than the essay she would normally assign. This suggests knowledge of how to use multimedia technology to deliver content as well as the ability to design multimedia-based and student-centered activities that are specific to their English content, including the ability to transfer that understanding to new tools that the participant had not encountered before. These practices are consistent with stronger TCK, TPK, and TPACK (Jamieson-Proctor et al., 2013; Mishra & Koehler, 2006) and were not as clearly evident at the beginning of the study.

Changes in beliefs. Danielle's self-reported statements reflect a different perception of and comfort with TEL instruction between the start and conclusion of the study. During the prestudy focus group interview, for example, Danielle emphasized how digital tools help her provide immediate feedback to students and argued that digital tools are too difficult for students to use by noting how students "do not like to read digital books" and that "annotating is still really difficult in the digital setting." Later, during a debrief of the first observation in her classroom, she suggested that there were student limitations to implementing student-centered practices in English by noting that:

> even if you're trying to crowbar it some way to get conceptual understanding tied into it because it's just so basic that we're still at a spot where that needs to happen…. And I don't know if there's a way to do that [pause] because part of it is developmental.

These statements all suggest that, prior to the intervention, Danielle saw technology primarily as a tool for facilitating organization and communication in her classes while perceiving genuine barriers to integrating elements of SCL instruction.

In contrast, Danielle reported perceiving more affordances for learning as a result of TEL instruction at the conclusion of the study. For example, Danielle reported student benefits from collaboration and that technology opened new doors to "who you can share with, who you can collaborate with" on the TPACK survey. She also discussed how TEL practices helped facilitate student ownership in learning. In her words:

> They know more than we do, and it was a good learning experience for them to realize that we're not experts in everything, but we can learn from them. Learning is a process that as teachers we're not afraid to give up a little bit of that control, and to use their expertise.

Statements such as these suggest that Danielle perceived TEL practices as benefitting student learning in a way that was not clear to them at the start of the study. They also suggest that Danielle's sense of efficacy evolved during the course of the study. This assertion is supported by her poststudy statements, such as when discussing modeling practices within her class, that "learning is a process that as teachers we're not afraid to give up a little bit of that control…And I think it might build confidence in them to see that, oh okay, I am an expert here and I can learn too."

TEL integration. The lessons observed in Danielle's class emphasized practices consistent with direct instruction. The first lesson, for example, consisted primarily of Danielle asking questions designed to check student understanding of existing knowledge. In this case, Danielle spent most of the lesson asking students questions about Gothic literature as well as directing them to discuss elements from the short story they read in the prior class session. She also incorporated student use of digital technology, first through an online quiz and later when students were asked to complete a Google Form to analyze data from a literature survey that they recently completed. The practice of guiding instruction through directed questions that are designed to check for understanding limits the ability of students to engage in collaborative problem solving that is a hallmark of SCL practice (Dole et al., 2016). Similarly, the use of digital technology to gather information and feedback from students, in this lesson, did not permit students to use digital tools as a central agent to promote inquiry and active engagement with content in a manner consistent with of TEL (Wang & Hannafin, 2005).

The second lesson in Danielle's class also incorporated student use of technology but not in a manner consistent with TEL. During this lesson students were engaged in two simultaneous tasks, reviewing feedback on a recent essay and recording a speech to be included as part of a grade-level project. Danielle spent much of the period calling individual students up to her desk to discuss drafts of a recent essay and provide feedback to the student. While she was holding these conference sessions, students were engaged in the process of finalizing and uploading a recording of a speech they created to be displayed on a grade-level website designed to highlight the skills that the students were learning in 10th-grade. The speech students were uploading was a one-minute argument on the topic of freedom. Although the task asked students to investigate a topic related to their world, restrictions placed on how they responded to the prompt (e.g., they could only use the text provided by the teacher as evidence and had to limit their personal commentary to their reactions to the text) kept this from being an authentic task (Slepkov, 2008).

Although the first two lessons observed in Danielle's class incorporated some aspects of SCL practices and student use of technology, the final lesson was predominantly teacher directed. She started the lesson with an overview of vocabulary specific to video production to help guide students in effectively analyzing a film such as the one that the class was currently reviewing. Danielle guided this discussion through a series of questions she asked individual students. Following this discussion, she showed three specific scenes from a Hitchcock movie and asked students to analyze the scenes. After showing each scene, Danielle broke the class into groups and asked each group to analyze a specific element of the scene. Although this final activity demonstrates some collaboration amongst students, the task did not emphasize the creative and critical thinking that is a hallmark of authentic tasks. Students were also not asked to engage with digital technology to facilitate their learning within the task.

Summary. The case studies compiled here detail the experiences of these four participants over the course of the intervention study. Their experiences display, in a more comprehensive manner, many of the challenges, questions, and changes that most of the other participants reported. In particular, the experiences of Eric, Richard, and Danielle help to detail the different understanding and set of beliefs toward TEL that many participants held between the start and conclusion of the study. Vanessa's experience, on the other hand, helps to understand the intervention from the perspective of a participant who reported strong knowledge and beliefs about TEL at the start of the PD and few differences by the conclusion of the study.

To fully address each research question, the findings within these case studies are combined below with both quantitative and qualitative evidence reported by the remaining participants.

Teacher Knowledge of TEL Practices (RQ2)

To understand the impact of the intervention on participants' PCK, TCK, TPCK, and TPACK, participant comments from the TPACK survey, focus group interviews, and classroom observations were analyzed through repetitive coding cycles. These qualitative data indicated that six of the participants generally reported new understanding of how to guide SCL practices, use multimedia technologies to deliver content to students, use multimedia technologies to support instruction within their content area, and use multimedia-based SCL activities to drive student learning within their specific content area. The differences were most pronounced among the mathematics and social studies teachers as well as three of the five English teachers. Two English teachers, on the other hand, did not complete the intervention and reported no real changes in this their knowledge or beliefs. Meanwhile, both science teachers, consistently demonstrated strong PCK, TCK, TPK, and TPACK as well as positive beliefs toward TEL throughout the study but still reported moderate differences in their TPK, TPACK, and beliefs at the conclusion of the study.

Most participants, such as Richard, were able to speak in more specific terms and at greater length about their practices by the conclusion of the study, which may provide evidence for modifications to their PCK and other forms of knowledge (van Driel et al., 1997). For example, three of the English teachers spoke broadly about using modeling and teacher lectures as tools to guide student learning in any subject area. At the conclusion of the study, however, they talked more specifically about the value of student projects and collaboration in guiding learning in English. These shifts are consistent with student-centered knowledge as defined by

Verloop et al. (2001) as well as changes in PCK (Shulman 1986; 1987). In a similar manner, in the prestudy surveys and interviews both mathematics teachers only discussed the use of calculators and the Notability app on their iPad as tools for delivering content. Similar to Richard, they also seemed initially uncertain of the potential for multimedia tools to support student-centered practices in their subject area. At the conclusion of the study, however, both teachers talked more extensively about new tools that they now saw as useful in their classes, including self-guided presentations and infographics. Richard similarly noted the potential for multimedia tools, including augmented reality applications, to make content more relevant in his social studies classes. These differences suggest an evolution in these teachers' understanding of how to deliver content through multimedia technology, consistent with new TCK (Koehler & Mishra, 2009).

These differences in PCK and TCK, however, did not uniformly transfer to changes in TPK. As was previously noted, Richard and Danielle displayed a stronger sense of how to use multimedia tools, including infographics and websites, to engage students in learning social studies and English. The two science teachers, comparably, evinced a deeper knowledge of student needs and limitations in using technology as well as the ability to adjust their practices to account for those limitations. Both mathematics teachers, in contrast, continued to emphasize the use of digital tools to facilitate grading and make content accessible to students outside of class for extended practice, through self-guided presentations. Although this reflects greater understanding of self-guided presentations as a communication tool, it does not suggest greater familiarity with how to use such presentations to enrich student learning, which would be indicative of new TPK (Harris et al., 2009).

In a similar manner, several participants reported minimal or no difference in their understanding of how SCL practices and multimedia technologies could be combined to support student learning (i.e., TPACK). Data from interviews and the TPACK survey, for example, indicated few significant changes, pre and poststudy, in how both mathematics teachers viewed multimedia technologies or SCL practices. Eric, as noted above, continuously emphasized the use of his iPad to demonstrate how to solve problems. His teaching partner in mathematics likewise talked broadly, in both the pre and poststudy data, about how the calculator application Desmos could be used to guide learning in mathematics and, in the poststudy focus group interview limited his discussion of multimedia technologies to the use of self-guided presentations to facilitate practice of concepts outside the classroom. Such practices suggest a continued focus on directed instruction and few changes in his TPACK.

Teacher Beliefs and Attitudes Toward TEL (RQ3)

To understand the impact of the intervention on participants' beliefs toward TEL instruction, quantitative data were collected using two scales on the TTF-TPACK survey, one that identified the extent to which participants found TEL practices useful and the other that examined their confidence using TEL practices, as well as a confidence scale on the TPACK survey created for this study. Qualitative data were collected from the TPACK survey, focus group interviews, and classroom observations. Although the quantitative analyses are held tentatively because of the small number of participants, statistical analyses resulted in no significant differences in teachers' perceptions of the usefulness of introducing TEL practices but a significant, if moderate, change in their sense of efficacy toward TEL. Although mean scores on the usefulness scale from the TTF-TPACK survey increased between the prestudy ($M = 4.03$, $SD = 0.92$) and poststudy ($M = 4.44$, $SD = 0.58$), a Wilcoxon Signed-Rank Test indicated that these differences were not statistically significant (z = -1.186, p = 0.236). On the other hand, results from confidence scale on the same survey indicated that participants reported changes in their sense of efficacy toward TEL pedagogies (z = -2.266, p = 0.023) between the pre (M = 3.59, SD = 0.71) and poststudy (M = 3.88, SD = 0.84) applications. Additionally, participants reported somewhat greater confidence in their ability to use the specific multimedia tools that were demonstrated in the intervention (z = -2.316, p = 0.021) on the TPACK Survey. Mean scores on this instrument changed from M = 3.14 (SD = 1.34) in the prestudy to M = 3.76 (SD = 1.29) in the poststudy.

Qualitative data collected from surveys, focus group interviews, and interviews with case study participants following classroom observations suggest that participants perceived fewer barriers to implementing TEL practices and saw greater affordances from these practices at the end of the intervention than they did before the intervention began. They also support the conclusion that participants generally gained greater confidence in using technology as well as in integrating TEL practices.

At the start of the intervention participants identified a number of barriers to TEL in their mathematics classes, including student limitations, concerns about student engagement, and limitations imposed by their curriculum. Danielle and the other English teachers, for example, emphasized how digital tools were difficult for students to use effectively to learn and that directed instruction was needed because students were not developmentally ready to learn through inquiry-based or other SCL practices. Richard similarly worried about the ability of students to engage in group work effectively and didn’t see application for multimedia technology to support student learning. Likewise, Eric discussed how students in his mathematics classes didn’t like it when he integrated SCL practices, such as in collaborative projects, while the other mathematics teacher stated how students really "like when I go old school and actually use the whiteboards to communicate information." Teachers of English and mathematics also emphasized how the content-specific skills students needed support in precluded TEL. As one mathematics teacher stated

> …they're almost throwing out skills. So, you still have to have skills in order to do those things and to be able to understand the greater concept. And… for at least the algebras and geometry, we're talking about skill-building courses that [sic] these are important skills that they need for advanced math concepts.

This sentiment, similar to those of English teachers, suggest that these teachers perceived the nature of their curriculum as a barrier to integrating TEL practices.

At the conclusion of the study, however, almost all of the participants emphasized the affordances they perceived from TEL instruction rather than the barriers they had initially noted. Although the two mathematics teachers still emphasized a need for repetition within mathematics instruction, they also noted how students were more engaged through the incorporation of SCL practices as well as the use of multimedia technology to deliver content and facilitate learning. For example, one mathematics teacher noted how authentic tasks, an element of SCL instruction, "could be a great tool to get students to think about how to use the knowledge they have to solve the problem." Similarly, the English teachers still saw technology as supporting some organizational aspects of teaching. One participant, for instance, noted how "I realized I don't really need copies of this…. I need one copy because it is digital." Most of the English teachers also evinced a greater focus, however, on how technology and SCL practices could be used to facilitate learning in their classes. Danielle, for instance, reported how students benefitted from collaboration. Similarly, another English teacher noted how a project requiring students to create infographics “brought everything into focus” for students.

In contrast to most of the participants, the two science teachers consistently identified strong affordances related to TEL instruction in their classes throughout the study. Both participants, for instance, consistently identified the real-world application of learning provided by TEL as strengthening student learning in their classes and that TEL practices increased student engagement. Vanessa emphasized how TEL practices encouraged students to take ownership of their learning while the other science teacher stated that TEL instruction “increases intrigue, investment, and simultaneously reduces students’ affective filters, consequently improving student participation and retention.” One small point of divergence was noted, however, between these two participants, in regard to their reported sense of efficacy. Although the other science teacher consistently reported a strong sense of efficacy toward both SCL practices as well as technology integration throughout the study, Vanessa reported greater confidence in her ability to facilitate SCL practices in her classes, as noted in the case study above.

In addition to Vanessa, other teachers also reported pre- and poststudy differences in their sense of efficacy toward TEL practices. Where they were initially hesitant about both the usefulness of TEL practices as well as their ability to facilitate suggested practices, Danielle and Eric both spoke more clearly and specifically about the role that TEL practices could play in their classes at the conclusion of the study. Richard, similarly, displayed new confidence at the end of the study as he actively sought out new technologies to incorporate in his classes (e.g., augmented reality). This was a notable contrast from his earlier assertions that digital technology had limited use in guiding instruction in social studies. This suggests both a different perception of the role that TEL practices could play in their instruction as well as new confidence with regard to their ability to guide student learning through TEL (Pederson & Liu, 2003).

Changes in confidence were also evident in participant responses on the TTF-TPACK survey, from $M = 3.14$ ($SD = 1.34$) in the prestudy to $M = 3.76$ ($SD = 1.29$) in the poststudy. This suggests that participants felt somewhat more confident in their ability to use technology and authentic tasks and using technology to guide student learning in their classes. Of particular note was the difference, from $M = 3.2$ ($SD = 0.78$) on the prestudy survey to $M = 4.1$ ($SD = 0.99$) on the poststudy survey, in participant comfort in guiding student learning through collaborative tasks ($z = -2.46$, $p = 0.14$), a critical element of SCL (Hmelo-Silver et al., 2007). Table 5.2 displays the results, pre and poststudy, from the relevant items on the confidence scale.

Table 5.2
Mean Participant Responses Related to Perception of their Confidence toward TEL (n=10)

Prompt	Pre *M* (*SD*)	Post *M* (*SD*)
How confident are you that you have the knowledge, skills, and abilities to teach specific subject areas in creative ways?	3.9 (1.10)	4.1 (0.99)
How confident are you that you have the knowledge, skills, and abilities to design technology-enhanced activities that enable students to become active participants in their own learning?	3.5 (0.70)	3.7 (0.94)
How confident are you that you have the knowledge, skills, and abilities to help students actively construct their own knowledge in collaboration with their peers and others?	3.2 (0.78)	4.1 (0.99)
How confident are you that you have the knowledge, skills, and abilities to help students acquire the knowledge, skills, abilities, and attitudes to deal with on-going technological change?	3.5 (0.97)	3.8 (1.22)
How confident are you that you have the knowledge, skills, and abilities to help students gather information and communicate with a known audience?	3.9 (0.87)	4.5 (0.70)

Note: Results from Wilcoxon Signed-rank test indicated statistical significance ($z = -2.46$, $p = 0.14$) for the prompt addressing participant comfort in guiding student learning through collaborative tasks.

The evidence presented here identifies how participants emphasized a newfound appreciation for TEL practices at the conclusion of the study rather than the barriers they perceived prior to participating in the intervention. Additionally, the evidence suggests that participants perceived new confidence in their ability to use multimedia technology to guide student learning and to engage students in SCL practices over the course of the intervention.

Implementation of TEL Practices (RQ4)

To investigate the extent that the intervention influenced participants to integrate elements of TEL within their instructional practices, observations were conducted in the four case study participants classrooms at the start and conclusion of the intervention as well as two months after the intervention was concluded. Following each observation, a debrief interview was conducted to provide additional insight into the instructional design practices and beliefs that guided those design practices. These observations revealed a shift in the instructional practices of three of the four case study participants. Eric and Vanessa demonstrated the most significant shifts in their practice, from predominantly teacher-directed instruction in the first lesson to practices consistent with TEL in the final observation. Richard emphasized SCL practices in all of the observations but embedded student use of technology to support those practices in the final lesson that had not been evident in the first two observations. In contrast, observations in Danielle's class demonstrated limited implementation of TEL practices. Though use of technology to support a task that was semi-authentic (i.e., the task asked students to investigate a topic relevant to their world but placed significant limitations on their ability to choose how to respond to that prompt) was noted during the second observation, there was no evidence of collaboration or reflection as part of the process. Conversely, collaboration was noted in the final observation but was not directed toward an authentic task.

A deeper examination of the debrief interviews following the classroom observations, however, suggests that the observed modifications in instructional practices may not be a product of the intervention. Eric, for instance, reported that the TEL-based lesson was only slightly modified from the previous year, requiring a more specific use of multimedia technology. Additionally, in the final debrief he continued to emphasize that learning within mathematics is best supported by repeated rounds of practice and review with specific problems. This belief, he reported, makes him hesitant to integrate TEL into his geometry classes. The debrief interview with Richard similarly revealed that the final lesson that incorporated elements of TEL had been enacted in his classes during previous years. The only modification that he noted was the requirement that groups use multimedia tools to deliver their content and facilitate audience engagement. Similarly, during the post observation interviews, Vanessa discussed how the first two lessons had been inspired by a recent PD program she had been involved with at the Aquarium of the Pacific, which emphasized ways to incorporate climate change lessons into high school science courses. She did report, however, that the multimedia elements in the second and third lesson were inspired by what she learned in the intervention. These revelations suggest that although the intervention supported some participants to integrate multimedia tools within their instructional practice, it had little impact on the pedagogical practices that teachers implemented within their lessons.

Discussion

This study sought to investigate whether a multimedia-based teacher PD program on SCL practices could support changes in teacher knowledge, attitudes, and beliefs toward TEL integration. At the conclusion of the study, most of the participants reported differences in their knowledge and beliefs toward TEL with a general trend toward stronger knowledge, perceived affordances, and confidence in their ability to integrate TEL practices. These changes were most notable in the mathematics and social studies teachers as well as in three of the English teachers. The two science teachers generally maintained strong knowledge as well as positive attitudes and beliefs toward TEL practices throughout the study. Meanwhile, the two English teachers who did not complete the application stage of the intervention reported no significant changes in their knowledge and beliefs. The differences noted in participant knowledge and beliefs did not translate into implementation of TEL practices in case study participants' lessons. Although classroom observations noted new instructional practices consistent with TEL, evidence from post observation interviews suggested that the observed instructional changes may have resulted from prior PD or reflected established practices for some participants. Full discussion of the results as well as connections to prior studies are organized by construct below.

Teacher Knowledge of TEL

The experiences of the case study participants exemplify the growth in PCK, TCK, TPK, and TPACK that most participants experienced over the course of the intervention. In particular, participants reported new understanding of how to guide instruction using SCL practices, how to integrate multimedia technologies within their instruction, and how to use both SCL practices and multimedia technology to create a TEL learning environment in their classrooms.

These findings are consistent with prior studies on multimedia-based PD to support teacher knowledge with regards to technology integration. Doering et al. (2014), for example, found that when teachers engage with technology to create presentations, their self-reported knowledge base relative to TPK and TPACK grew stronger. This was especially true when the teachers perceived their task to be authentic to their practice as teachers. Allan et al. (2010) and Minor et al. (2016) likewise found that PD that emphasized tasks teachers found authentic to their practice supported growth in TCK and TPK. The participants in the present study were required to engage with technology in an authentic manner by creating a multimedia presentation on content related to their courses. That most of them demonstrated differences in the various elements of TPACK seems to support this earlier research. Finally, the current findings support an observation made previously by Kafyulilo, Fisser, and Voogt (2015) that the use of exemplary lessons, expert guidance, and collaboration in technological tasks support growth in teachers' TPACK.

Prior studies have also noted, however, that teacher PD that relies on directed instruction, modeling of practices by expert practitioners, or cognitive apprenticeship alone may not be sufficient to impact teacher knowledge with respect to technology integration (Kafyulilo et al., 2015; Minor et al., 2016; Mouza, 2009). Teachers need to be actively engaged with technology through tasks they find authentic to their practices, including clear relevance to promoting student learning within their content area in order to build their understanding of how to use digital technology as a pedagogical tool to support SCL practices. In that light, it is notable that two participants were unable participate in the second stage of the intervention, which involved participation in an authentic task. While they were active participants in the instructional stage, they were not able to create their own multimedia presentation. These two participants also demonstrated no significant changes in their knowledge over the course of the study. This seems to validate the importance of active engagement with technology in supporting changes in the various forms of teacher technological knowledge. Merinick et al. (2009) and Minor et al. (2016), however, offer another explanation that may account for the lack of change exhibited by these participants. These researchers found that PCK was the core of teacher knowledge, particularly TPACK, and that teachers who did not exhibit strong PCK were unlikely to exhibit growth in other areas of teacher knowledge. Neither participant reported strong PCK at the start of this study nor did they evince new PCK as a result of participating in the study. Their lack of change related to technology integration may, therefore, be related to their limited PCK.

Teacher Beliefs Toward TEL

Data from the TPACK survey as well as interviews suggests that those participants who participated fully in both stages of the intervention saw fewer barriers to integrating such practices, greater affordances for student learning when TEL practices were integrated, and a stronger sense of confidence that they could implement such practices within their instructional context. Owing to their positive beliefs about TEL instruction at the start of the intervention, the two science teachers demonstrated fewer pre and poststudy differences in their beliefs than most of the other participants. The two English teachers who did not participate in the second stage of the intervention displayed few if any changes in their beliefs toward TEL, identifying more barriers than affordances to such practices at the start and conclusion of the study. These findings are consistent with earlier findings (Karolčik et al., 2016; McCaughtry et al., 2000a, b; Palak & Walls, 2009) that PD that includes expert modeling as well as collaboration and authentic tasks may support new beliefs toward TEL, particularly SCL practices and the use of digital technology to facilitate learning.

The data from both survey instruments as well as from interviews more strongly supports the conclusion that participation in a SCL and multimedia-based PD encourages changes in teacher sense of efficacy toward TEL. This was true even for Vanessa, who consistently identified strong affordances in using TEL practices both before and after the study. These findings were consistent with prior studies on multimedia-based PD to support teacher beliefs with regards to instructional changes. Skoretz and Childress (2013), for example, demonstrated that modeling of and practice with specific digital tools as part of teacher PD supported teachers' sense of efficacy when using technology to drive instruction. Kellerer et al. (2014) similarly found that teacher PD that involves engagement in tasks that teachers find authentic supports their sense of efficacy in transforming instructional practices. Finally, Palak and Walls (2009) noted the value of teacher collaboration within PD as a tool for building teacher efficacy toward technology integration.

TEL Implementation

Evidence from case study participants suggests that there was a modification in their instructional practices between the lessons observed at the start of the study and those observed a month after the study concluded. Specifically, although the first round of observations revealed a reliance on teacher-directed practices, the final round of observations, conducted approximately two months after the intervention concluded revealed instructional strategies consistent with TEL.

Prior research has noted that PD that emphasizes the use of authentic tasks to support changes in teachers' knowledge and beliefs makes TEL integration more likely. Doering et al. (2014), for instance, found that supporting teacher TPACK, in geography teachers, made it more likely that they integrated GeoThentic, an online teaching and learning platform for geography, into their instructional practice. Similarly, Kellerer et al. (2014) and Karolčik et al. (2016) found that supporting positive teacher perceptions of SCL practices and technology integration made it more likely that participants integrated practices consistent with TEL into their daily lessons. The findings reported in the present study seem, at first blush, to support these previous studies and suggest that participants were able to implement TEL within their classroom.

Participant reports during debrief interviews, however, suggest that the observed integration of SCL practices were the result of prior PD or established instructional practices and not a result of the intervention. Where differences were noted such changes appear to be the product of earlier PD or past practices rather than a result of the intervention. Based on these findings, I conclude that there were no shifts in instructional practices as a result of the intervention. As Mouza (2006) has noted, however, shifts in instructional practice with technology often take far longer to observe than changes in other factors, such as knowledge. Extended time working with TEL practices, outside established PD, has also been noted as having an impact on the long-term implementation of TEL (McKenney et al., 2015; Moore-Hayes, 2011). Thus, it is possible that additional implementation of TEL practices might be noted if data collection had extended beyond a month following the intervention.

Implications for the Design of Teacher PD

The teachers in the present study reported new knowledge, beliefs, and attitudes after participating in a SCL and multimedia-based PD. These findings support previous studies on technology integration (Doering et al., 2014; Palak & Walls, 2009) as well as instructional changes related to SCL practices (Minor et al., 2016; Ross & Bruce, 2007; Verloop et al., 2001) and TEL (Karolčick et al., 2016; Kellerer et al, 2014). In particular, the results illuminate how modeling, collaborative discussion, and engagement in authentic tasks with skilled guidance support the interconnected nature of teacher knowledge, attitudes, and beliefs toward TEL.

Participant statements within the exit surveys, TPACK survey, and interviews indicate that participants benefitted from the aspects of modeling that were incorporated into the intervention. Ross and Bruce (2007) previously reported how modeling teacher PD using the instructional practices that participants are intended to learn supports participants knowledge and beliefs toward those practices. Similarly, the participants in the current study remarked on the exit surveys about how SCL practices were “cleverly and expertly modeled by the instructor” as well as that “it was refreshing to see new strategies and techniques that can be utilized immediately.” As Karolčick et al. (2016) previously reported, such modeling helps teachers see clearly how student-centered and TEL practices can be implemented, thus leading to a reduction in the number of barriers to instructional changes reported by teachers. In this way, participants, having received training in SCL practices through a student-centered design, could look beyond previously conceived barriers and build stronger PCK while noting greater affordances to student learning from SCL practices.

Additionally, the example multimedia presentations that were used to explain SCL practices provided teachers with a model of message design that they could use to support student learning. As one participant put it "It was helpful to see multiple examples of media that I can use to both present information to my students and to have my students use for presentations." This was further supported by the incorporation of the CTML model that participants could use to examine these presentations more closely. As another participant noted "the modeled lens of using coherence, contiguity, balance, and personalization when I create future technology-based learning opportunities for my students" was the most valuable element of the intervention. In this way, the model presentations, combined with the incorporation of a tool that teachers could use to analyze the presentations more deeply helped these teachers to expand their TCK and TPK as well as identify greater affordances related to incorporating multimedia technology into their instruction.

In addition to the value of modeling as an element with teacher PD, the findings from this study also support previous research (Kafyulilo et al., 2015; Kellerer et al., 2014; Palak & Walls, 2009; Skoretz & Childress, 2013) related to how the inclusion of teacher collaboration within PD supports changes in teacher knowledge and beliefs toward new instructional practices. This collaboration was infused into both stages of the present intervention. In the instructional stage, participants engaged in collaborative evaluations of the model multimedia presentations. This collaboration allowed them to clarify and extend their thinking and thus come to a better understanding of both the SCL practices that were being discussed in the videos as well as the multimedia tools that were used within the presentations. "The discussions were valuable to the staff as a whole I believe," as one participant reported. Additionally, participants were given the opportunity to collaborate on the multimedia presentation that they created in the application stage of the intervention. All but one participant chose to take advantage of this prospect. Through this collaboration they were able to decrease their workload while reducing the cognitive load that comes from working with new technology.

The present findings also confirm prior research on using authentic tasks to build teacher TPACK (Allan et al., 2010; Doering et al., 2014) support teacher beliefs toward TEL (Karolčick et al., 2016) and build teacher efficacy toward TEL (Pan and Franklin, 2011). By asking teachers to produce multimedia presentations they would use in their professional practice, they were able to apply what they learned in the instructional sessions, experiment with new forms of digital technology, and create relevant links to own instructional methods. One participant noted that this intervention was "one of the most practical, salient, and applicable forms of professional development I have received in my career," while another stated that "my students and I will be able to enhance all of our digital media… students [sic] will be able to master real-world skills." By engaging in such tasks, these participants built a deeper understanding of TEL practices while challenging previously conceived barriers and supporting their sense of efficacy in using both technology as well as TEL practices.

Finally, the current findings validate earlier findings by Ertmer (2005) and Pedersen and Lui (2003) of how reflection encourages a more positive attitude toward instructional changes, in general, and TEL practices, in particular. As one participant noted "the opportunity to reflect on the effectiveness of the presentations" was the most valuable part of the intervention. "While this reflection directly applies to the presentations, it has also provided the chance for me to think about how I present information to students and how other methods might be more effective." This statement points to how the ability to reflect upon their learning allowed participants to deepen their understanding of the content that was presented as well as how technology could be used to support student learning.

The results thus suggest that designers of teacher PD, especially PD that is geared to changing teachers' knowledge and beliefs regarding the pedagogical practices that are at the core of 21st-century learning (Gunn & Hollingsworth, 2013), would benefit from using models of new technology, providing teachers with a tool to further analyze those models within their professional context, and creating the learning opportunities that they seek to have teacher implement within their classrooms. The inclusion of authentic tasks that teachers collaborate on should also be prioritized, allowing teachers to deepen their understanding of the practices at the heart of the PD and share the cognitive load and time commitment to complete the task. Finally, careful attention should be paid to providing opportunities for teachers to reflect upon what they learned and how it applies to their instructional practice. Such changes may help overcome the gap between teacher PD and modifications to instructional practice that has long been noted in teacher learning (Macià & García, 2016; Merinik et al., 2009; Putnam & Borko, 2000).

Implications for Professional Practice

The process, chronicled through this dissertation, of examining a problem of practice through a systematic approach, implementing an intervention in an attempt to address that problem, creating a study to investigate the effectiveness of that intervention, and reporting on the findings of that study have had a significant impact on my role as an educator and future administrator. In particular, it has informed my understanding of teacher PD at a deeper level. I served as a PD coach in my district for seven years prior to beginning my doctoral studies. Looking back, I appreciate more fully the assertion by Ball and Cohen (1999) that most teacher PD is the equivalent to “yo-yo dieting” (p. 4). The other coaches and I often designed PD that emphasized short-term practices that we hoped would implement long-term changes without a full understanding of the cognitive processes that would support such changes. We felt pressure, from the macrosystem that I identified in Chapter One, to make quick changes that would satisfy policy requirements. I now appreciate that instructional reforms are a slow process that require a deep understanding of the cognitive considerations embedded within those changes. I hope to one day be in a position, again, to guide teacher PD and help construct the long-term instructional reforms that my study showed the potential to create.

In a similar vein, working through the inevitable complications that came with guiding a PD program at a school site helped me to better appreciate how teacher learning is situated within multiple contexts (McKenney et al., 2015). Teachers have many demands placed upon them that impact their ability to learn, especially when that learning is directed within a specific timeframe. I came to see how, as a future administrator and guide for teacher learning, I need to be flexible and prioritize the needs of teachers within the learning process. Crafting professional learning opportunities that consider the situated nature of teacher learning not only will support the likely success of that learning experience (Putnam & Borko, 2000) but also mirror the situated nature of student learning (Lave, 1996) that I hope teachers under my leadership will account for in their own instructional practices.

Finally, and most impactfully, the full process of examining and acting upon a problem within the instructional environment through disciplined inquiry has made me a strong advocate for the use of improvement science (Bryk et al, 2015; Perla et al., 2013) in guiding reform efforts within schools. In all of my prior experience, including in leading the accreditation process for my school, I was never exposed to how cycles of learning and testing changes could be combined to drive a systematic process of reform. Moving forward, my goal is to work to implement the various principles of improvement science wherever I go as well as to actively inform other educators about the power of guiding change through these practices.

Study Limitations

This study had limitations based the characteristics of the district, the size and organization of the school, the research design, and the collection of data. The district is located in a high socioeconomic area and CMC is a small school with fewer than 500 students and only 13 teachers. The school also encourages cross-curricular collaboration among teachers through grade-level teaming. The small sample size prohibited the use of rigorous statistical tests and limited the strength of the conclusions that can be drawn from quantitative data (Cresswell & Plano-Clark, 2011). As was noted in Chapter Four, my position as a teacher leader in the school may also have influenced participants to provide socially acceptable responses on surveys and in interviews rather than their authentic views. Similarly, case study participants may have altered their instructional practices with the knowledge that I was coming in to observe them.

I observed in Chapter Four how Koehler et al. (2012) and others have noted particular difficulty in measuring the constructs of TPACK using quantitative methods as a rationale for relying on qualitative measures to assess changes in knowledge within this study. While triangulation amongst the multiple qualitative measures lends weight to the conclusions drawn from these sources, it is possible that different or more nuanced conclusions could have been reached through the inclusion of valid quantitative methods. The importance of trying to identify such measures was stressed by Chai et al. (2011) as well as Koehler et al. (2012) in light of the academic community's continued use of TPACK as a construct.

Finally, as was noted in the discussion of TEL implementation, the timeframe of the study may have limited the accuracy of data collected with regard to long term outcomes. A longer timeframe would also have provided participants with more time to engage with the multimedia tools, which prior research has demonstrated to support changes in teacher TEL knowledge and beliefs, especially self-efficacy (Ertmer, 2005; Kellerer et al., 2014; Moore-Hayes, 2011).

Summary

In light of how most teacher training and PD is ineffective in transforming instructional practices (Attia, 2014; Putnam & Borko, 2000), the findings from the current study provide some insight into how to design teacher PD to support instructional change, especially the inclusion of TEL practices. In particular, the findings reported here suggest that teacher learning benefits from the inclusion of modeling, collaborative discussion, and engagement in authentic tasks with expert guidance within teacher PD. In the context of the recent push to support 21st-century learning as well as the TEL practices that are central to this shift, finding ways to support teacher cognition to implement TEL are essential.

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Appendix A

CLARITY SURVEY OF TECHNOLOGY USE BY STUDENTS AND TEACHERS

Student Survey Questions

1. How often do you use computer devices, such as desktops, laptops, or tablets, in class?
   - Almost Daily
   - Weekly
   - Monthly
   - Every Few Months
   - Never

2. Do you have a school-provided computer device, such as a laptop or tablet?
   - Yes, and I can take it home every night
   - Yes, and I can sometimes take it home
   - Yes, but I can't take it home
   - No, I don't have one

3. Do you personally own any of the following devices?

   Desktop Computer
   - Yes, and I am the only user
   - Yes, and I share it
   - No

   Laptop computer, such as a Chrombook or MacBook
   - Yes, and I am the only user
   - Yes, and I share it
   - No

   Tablet computer, such as an iPad or Nexus
   - Yes, and I am the only user
   - Yes, and I share it
   - No

   Smartphone, such as an iPhone or Samsung Galaxy
   - Yes, and I am the only user
   - Yes, and I share it
   - No

   eReader, such as a Kindle
   - Yes, and I am the only user
   - Yes, and I share it

- No

Digital camera (photo or video)
- Yes, and I am the only user
- Yes, and I share it
- No

Media device, such as Apply TV or Chromecast
- Yes, and I am the only user
- Yes, and I share it
- No

4. Do you have Internet access at home?
- Yes
- No

5. Is your Internet at home wireless?
- Yes
- No

6. How do you primarily connect to your wireless network?
- Via cellular networks
- Via a wireless router (Wi-Fi)
- I don’t know

7. How easy is it for you to do the following?

Send emails
- Very easy
- Easy
- Moderate
- Hard
- I don’t know how to do this

Connect a printer to a device
- Very easy
- Easy
- Moderate
- Hard
- I don’t know how to do this

Create spreadsheets
- Very easy
- Easy
- Moderate

- Hard
- I don’t know how to do this

Edit photos
- Very easy
- Easy
- Moderate
- Hard
- I don’t know how to do this

Record and edit audio
- Very easy
- Easy
- Moderate
- Hard
- I don’t know how to do this

Record and edit video
- Very easy
- Easy
- Moderate
- Hard
- I don’t know how to do this

Download and install software and apps
- Very easy
- Easy
- Moderate
- Hard
- I don’t know how to do this

Collaborate using online documents, such as Google Docs or Dropbox
- Very easy
- Easy
- Moderate
- Hard
- I don’t know how to do this

Use web tools to receive online information, such as Twitter or news feeds
- Very easy
- Easy
- Moderate
- Hard
- I don’t know how to do this

8. Do you agree with the following statements

I learn technology easily

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

When I am confronted with a technology related problem, I usually find good solutions

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

9. How often do you do the following?

Upload a photo from a camera or phone

- Almost Daily
- Weekly
- Monthly
- Every Few Months
- Never

Download or stream music, podcasts or other audio

- Almost Daily
- Weekly
- Monthly
- Every Few Months
- Never

Play games on your computer, tablet, or smartphone

- Almost Daily
- Weekly
- Monthly
- Every Few Months
- Never

Send text messages

- Almost Daily
- Weekly
- Monthly
- Every Few Months

- Never

Buy things online, such as apps, songs or clothing

- Almost Daily
- Weekly
- Monthly
- Every Few Months
- Never

Look at friends' photos or videos online

- Almost Daily
- Weekly
- Monthly
- Every Few Months
- Never

Chat online, such as using Facebook messenger or FaceTime

- Almost Daily
- Weekly
- Monthly
- Every Few Months
- Never

Read things on the internet, such as blogs and news sites

- Almost Daily
- Weekly
- Monthly
- Every Few Months
- Never

Write online, such as reviews, blog posts, and comments

- Almost Daily
- Weekly
- Monthly
- Every Few Months
- Never

10. How often do you use the following social networks?

Facebook

- Almost Daily
- Weekly
- Monthly
- Every Few Months
- Never

Google+
- Almost Daily
- Weekly
- Monthly
- Every Few Months
- Never

LinkedIn
- Almost Daily
- Weekly
- Monthly
- Every Few Months
- Never

Twitter
- Almost Daily
- Weekly
- Monthly
- Every Few Months
- Never

11. If you want to learn more about something, how often would you do the following?

Ask a question on a social network, such as Facebook or Twitter
- All of the time
- More than half of the time
- Less than half of the time
- Rarely
- Never

Search the Internet, such as Google, Bing or YouTube
- All of the time
- More than half of the time
- Less than half of the time
- Rarely
- Never

Buy a book
- All of the time
- More than half of the time
- Less than half of the time
- Rarely
- Never

Ask a friend or teacher
- All of the time
- More than half of the time
- Less than half of the time
- Rarely
- Never

Go to the library
- All of the time
- More than half of the time
- Less than half of the time
- Rarely
- Never

12. Who has talked with you about responsible Internet and cell phone use? (Check all that apply)
    - A parent or guardian
    - A teacher or other adult at school
    - A sibling or other family member
    - A friend or schoolmate
    - A trusted adult, such as a coach
    - A librarian
    - I researched it on my own, such as through websites
    - No one has talked to me about this

13. How often do a majority of your teachers ask you to do the following

    Collaborate using online documents, such as Google Docs or Dropbox
    - At least weekly
    - Monthly
    - Every few months
    - Never

    Collaborate online with classmates
    - At least weekly
    - Monthly
    - Every few months
    - Never

    Collaborate online with students at other schools
    - At least weekly
    - Monthly
    - Every few months
    - Never

14. How often do a majority of your teachers ask you to do the following?

Write for an online audience, such as reviews, comments, or blog entries
- At least weekly
- Monthly
- Every few months
- Never

Receive feedback digitally from classmates
- At least weekly
- Monthly
- Every few months
- Never

Receive feedback digitally from someone other than your teacher, such as a classmate or expert outside of school
- At least weekly
- Monthly
- Every few months
- Never

Chat online using tools such as Skype, Google Hangout, or FaceTime
- At least weekly
- Monthly
- Every few months
- Never

Collaborate online with your teachers
- At least weekly
- Monthly
- Every few months
- Never

Use webtools to receive online information, such as Twitter or news feeds
- At least weekly
- Monthly
- Every few months
- Never

15. How often do a majority of your teachers ask you to do the following?

Use a digital camera (photo or video)
- At least weekly
- Monthly
- Every few months

- Never

Develop multimedia presentations using technology
- At least weekly
- Monthly
- Every few months
- Never

Create art, music, movies, or webcasts using technology
- At least weekly
- Monthly
- Every few months
- Never

Post your schoolwork online, such as in an ePortfolio or to a class blog
- At least weekly
- Monthly
- Every few months
- Never

Create online models, simulations or animations
- At least weekly
- Monthly
- Every few months
- Never

16. How often do a majority of your teachers ask you to do the following?

Do research online
- At least weekly
- Monthly
- Every few months
- Never

Take measurements or do experiments using technology
- At least weekly
- Monthly
- Every few months
- Never

Identify and solve authentic problems using technology
- At least weekly
- Monthly
- Every few months
- Never

Collect and analyze data using technology

- At least weekly
- Monthly
- Every few months
- Never

17. How often do a majority of your teachers teach you about the following?

How to cite information I find online (articles, images, videos, audio)

- At least weekly
- Monthly
- Every few months
- Never

How to share information about myself online

- At least weekly
- Monthly
- Every few months
- Never

How to act responsibly online

- At least weekly
- Monthly
- Every few months
- Never

How to respond to online bullying

- At least weekly
- Monthly
- Every few months
- Never

18. What are the major obstacles to using technology in school? (Check all that apply)
- I don't have the necessary skills
- My classes don't require using technology
- School technology isn't good enough
- School rules limit my technology use
- My school has different computers or software than I am used to
- There are no obstacles

19. Are you part of a group at school that helps people using technology, such as fixing computers, updating software, and answering people's questions?
- Yes
- No

20. How strongly do you agree with the following statements?

Technology in the classroom enhances my learning

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

I think that learning is more engaging when using technology

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

My school encourages technology use for learning

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

I want to know more about technology use for learning

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

I think that computers and technology make my life better

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

21. What grade are you in?

- 9th Grade
- 10th Grade
- 11th Grade
- 12th Grade

Teacher Survey Questions

22. Which of the following best describes your role at the school?
    - Teacher
    - Administrator
    - Other (e.g., part-time teacher, para-teacher)

23. How often can you access the following school- or district-provided technologies for YOUR USE in class?

    Desktop computer
    - All of the time
    - More than half of the time
    - Less than half of the time
    - Rarely
    - Never

    Laptop computer (e.g., Chromebook or MacBook)
    - All of the time
    - More than half of the time
    - Less than half of the time
    - Rarely
    - Never

    Tablet computer (e.g Ipad or Nexsus)
    - All of the time
    - More than half of the time
    - Less than half of the time
    - Rarely
    - Never

    An LCD projector or interactive whiteboard
    - All of the time
    - More than half of the time
    - Less than half of the time
    - Rarely
    - Never

    A digital camera (photo or video)
    - All of the time
    - More than half of the time
    - Less than half of the time
    - Rarely
    - Never

Access to a wireless network (Wi-Fi)
- All of the time
- More than half of the time
- Less than half of the time
- Rarely
- Never

24. Do you have a school- or district-provided device (e.g., laptop or tablet)?
    - Yes, and I can take it home every night
    - Yes, and I can sometimes take it home
    - Yes, but I can't take it home
    - No, I don't have this

25. How often do you students use computer devices (desktops, laptops, tablets) in class?
    - Almost daily
    - Weekly
    - Monthly
    - Every few months
    - Never

26. On average, what is the student-to-device (desktop, laptop, tablet) ratio available for your students (in your classroom, labs, and from carts)?
    - 1 student to 1 computer
    - 2 students to 1 computer
    - 3 students to 1 computer
    - 4 students to 1 computer
    - 5 students to 1 computer
    - There are no devices available to my students

27. Where do these devices come from?
    - Classroom (i.e your classroom has enough dedicated devices, both school- and student-owned, to meet your daily needs).
    - Classroom + Cart (i.e., your classroom has a few dedicated devices but you need to borrow additional devices from time to time).
    - Cart (i.e., your classroom has no dedicated devices but you can borrow them for use in your classroom)
    - Lab (i.e., your classroom has no dedicated devices and you go to a separate location for access, such as a library).

28. How frequently can you access computer devices (desktops, laptop, tablets) for your student's use?
    - All of the time
    - More than half of the time
    - Less than half of the time
    - Rarely

- Never

29. Does your school or district provide you with any of the following digital options?

    An online space where teachers can distribute materials to students
    - Yes, and I can access it at home and at school
    - Yes, and I can access it at school only
    - No, we don't have this

    An online place where teachers can access and share materials with colleagues
    - Yes, and I can access it at home and at school
    - Yes, and I can access it at school only
    - No, we don't have this

    A system for entering and viewing grades
    - Yes, and I can access it at home and at school
    - Yes, and I can access it at school only
    - No, we don't have this

    A system for entering and viewing attendance records
    - Yes, and I can access it at home and at school
    - Yes, and I can access it at school only
    - No, we don't have this

    A system for entering and viewing Individual Education Plans (IEP's)
    - Yes, and I can access it at home and at school
    - Yes, and I can access it at school only
    - No, we don't have this

    A system for administering and viewing digital assessments
    - Yes, and I can access it at home and at school
    - Yes, and I can access it at school only
    - No, we don't have this

30. Do you personally own any of the following devices?

    Desktop computer
    - Yes, and I am the only user
    - Yes, and I share it
    - No

    Laptop computer (e.g., Chromebook or MacBook)
    - Yes, and I am the only user
    - Yes, and I share it
    - No

Tablet computer (e.g., iPad or Nexus)
- Yes, and I am the only user
- Yes, and I share it
- No

Smartphone (e.g., iPhone or Samsung Galaxy)
- Yes, and I am the only user
- Yes, and I share it
- No

eReader (e.g., Kindle)
- Yes, and I am the only user
- Yes, and I share it
- No

Digital camera (photo or video)
- Yes, and I am the only user
- Yes, and I share it
- No

Media device (e.g., AppleTV or ChromeCast)
- Yes, and I am the only user
- Yes, and I share it
- No

31. Do you have Internet access at home?
    - Yes
    - No

32. Is your Internet at home wireless?
    - Yes
    - No
    - I don't know

33. How do you primarily connect to your wireless network?
    - Via cellular networks
    - Via wireless router (Wi-Fi)
    - I don't know

34. How easy is it for you to do the following?

    Send emails
    - Very easy
    - Easy

- Moderate
- Hard
- I don’t know how to do this

Connect a printer to a device
- Very easy
- Easy
- Moderate
- Hard
- I don’t know how to do this

Create spreadsheets
- Very easy
- Easy
- Moderate
- Hard
- I don’t know how to do this

Edit photos
- Very easy
- Easy
- Moderate
- Hard
- I don’t know how to do this

Record and edit audio
- Very easy
- Easy
- Moderate
- Hard
- I don’t know how to do this

Record and edit video
- Very easy
- Easy
- Moderate
- Hard
- I don’t know how to do this

Download and install software and apps
- Very easy
- Easy
- Moderate
- Hard

- I don't know how to do this

Collaborate using online documents (e.g Google Docs or Dropbox)
- Very easy
- Easy
- Moderate
- Hard
- I don't know how to do this

Use web tools to receive online information (e.g., Twitter or news feeds)
- Very easy
- Easy
- Moderate
- Hard
- I don't know how to do this

35. Indicate how strongly you agree or disagree with the following statements.

I learn technology easily
- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

When I am confronted with technology related problems, I usually find a good solution
- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

I easily find new technologies to meet my teaching goals.
- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

I feel confident in managing a classroom where students are using technology
- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

36. How often do you do the following?

Upload photos from a camera or phone

- Almost daily
- Weekly
- Monthly
- Every few months
- Never

Download or stream music, podcasts or other audio

- Almost daily
- Weekly
- Monthly
- Every few months
- Never

Play games on your computer, tablet or smartphone

- Almost daily
- Weekly
- Monthly
- Every few months
- Never

Send text messages

- Almost daily
- Weekly
- Monthly
- Every few months
- Never

Make online purchases (e.g., apps, clothing)

- Almost daily
- Weekly
- Monthly
- Every few months
- Never

Look at friends' photos or videos online

- Almost daily
- Weekly
- Monthly
- Every few months
- Never

Chat online (e.g., Skype, Google Hangout, FaceTime)

- Almost daily
- Weekly
- Monthly
- Every few months
- Never

Read online content (e.g., blogs, news sites)

- Almost daily
- Weekly
- Monthly
- Every few months
- Never

Participate in webinars

- Almost daily
- Weekly
- Monthly
- Every few months
- Never

Write online (e.g., reviews, blog posts, comments)

- Almost daily
- Weekly
- Monthly
- Every few months
- Never

37. How often do you use the following social networks?

Facebook

- Almost daily
- Weekly
- Monthly
- Every few months
- Never

Google+

- Almost daily
- Weekly
- Monthly
- Every few months
- Never

LinkedIn

- Almost daily
- Weekly
- Monthly
- Every few months
- Never

Twitter
- Almost daily
- Weekly
- Monthly
- Every few months
- Never

Educational social networks (i.e., Edmodo, The Educators PLN)
- Almost daily
- Weekly
- Monthly
- Every few months
- Never

Pinterest
- Almost daily
- Weekly
- Monthly
- Every few months
- Never

38. If you want to learn more about something, how often would you do the following?

Ask a question in a social network (e.g., Facebook, LinkedIn, Twitter)
- All of the time
- More than half of the time
- Less than half of the time
- Rarely
- Never

Search the Internet (e.g., Google, Bing, YouTube)
- All of the time
- More than half of the time
- Less than half of the time
- Rarely
- Never

Buy a book
- All of the time

- More than half of the time
- Less than half of the time
- Rarely
- Never

Ask a friend or colleague
- All of the time
- More than half of the time
- Less than half of the time
- Rarely
- Never

Go to the library
- All of the time
- More than half of the time
- Less than half of the time
- Rarely
- Never

39. How often do you do the following for a majority of your classes?

Post course materials online
- At least weekly
- Monthly
- Every few months
- Never

Post homework online
- At least weekly
- Monthly
- Every few months
- Never

Use online audio content
- At least weekly
- Monthly
- Every few months
- Never

Use online video content
- At least weekly
- Monthly
- Every few months
- Never

40. How frequently do you ask a majority of your students to do the following?

Collaborate using online documents (e.g., Dropbox, Google Docs)
- At least weekly
- Monthly
- Every few months
- Never

Collaborate online with classmates
- At least weekly
- Monthly
- Every few months
- Never

Collaborate online with students at other schools
- At least weekly
- Monthly
- Every few months
- Never

41. How frequently do you ask a majority of your students to do the following?

Write for an online audience (e.g., reviews, blog posts, comments)
- At least weekly
- Monthly
- Every few months
- Never

Receive feedback digitally from peers
- At least weekly
- Monthly
- Every few months
- Never

Receive feedback digitally from someone other than you (e.g., an outside expert, a student in another class)
- At least weekly
- Monthly
- Every few months
- Never

Chat online (e.g. Skype, Google Hangout, FaceTime)
- At least weekly
- Monthly
- Every few months

- Never

Collaborate online with you
- At least weekly
- Monthly
- Every few months
- Never

Use web tools to receive information (e.g., Twitter, news feeds)
- At least weekly
- Monthly
- Every few months
- Never

42. How often do you ask a majority of your students to do the following?

Use a digital camera (photo or video)
- At least weekly
- Monthly
- Every few months
- Never

Develop multimedia presentations using technology
- At least weekly
- Monthly
- Every few months
- Never

Create art, music, movies or web casts using technology
- At least weekly
- Monthly
- Every few months
- Never

Post schoolwork online (e.g., use ePortfolios)
- At least weekly
- Monthly
- Every few months
- Never

Create online models, simulations, or animations
- At least weekly
- Monthly
- Every few months
- Never

43. How frequently do you ask a majority of your students to do the following?

Conduct research online
- At least weekly
- Monthly
- Every few months
- Never

Take measurements or do experiments using technology
- At least weekly
- Monthly
- Every few months
- Never

Identify and solve authentic problems using technology
- At least weekly
- Monthly
- Every few months
- Never

Collect and analyze data using technology
- At least weekly
- Monthly
- Every few months
- Never

44. How frequently do you use the following with a majority of your students?

Subject- or grade-specific software
- At least weekly
- Monthly
- Every few months
- Never

Digital assessments
- At least weekly
- Monthly
- Every few months
- Never

45. How frequently do you use the following with a majority of your students?

Interactive whiteboards or display devices (e.g., LCD projectors, large monitors)
- At least weekly

- Monthly
- Every few months
- Never

Digital polls (e.g. response clickers, online surveys)
- At least weekly
- Monthly
- Every few months
- Never

Digital textbooks
- At least weekly
- Monthly
- Every few months
- Never

46. How much time do you spend each year formally or informally teaching students about the following topics?

Creating an online presence
- More than 5 hours
- 3-5 hours
- 1-3 hours
- Less than an hour
- I don’t teach this

Legally using digital content
- More than 5 hours
- 3-5 hours
- 1-3 hours
- Less than an hour
- I don’t teach this

Preventing cyberbullying
- More than 5 hours
- 3-5 hours
- 1-3 hours
- Less than an hour
- I don’t teach this

Being safe online
- More than 5 hours
- 3-5 hours
- 1-3 hours
- Less than an hour

- I don’t teach this

Using social networks for learning
- More than 5 hours
- 3-5 hours
- 1-3 hours
- Less than an hour
- I don’t teach this

47. Assistive technologies (AT) enable individuals with special needs to be more independent, self-confident, productive, and better integrated into the mainstream. Do you currently have access to AT for your students?
    - Yes
    - No

48. Rate your knowledge of the following?

Creating an online presence
- Very high
- High
- Medium
- Low
- I don’t know about this

Legally using digital content
- Very high
- High
- Medium
- Low
- I don’t know about this

Preventing cyberbullying
- Very high
- High
- Medium
- Low
- I don’t know about this

Being safe online
- Very high
- High
- Medium
- Low
- I don’t know about this

49. When using the schools Internet, how often do the school's filters prevent you from accessing websites you need for your classes?
    - Never
    - Rarely
    - Less than half of the time
    - More than half of the time
    - All of the time

50. Rate the quality of the following technology products and services at your school.

    Internet speed
    - Excellent
    - Above average
    - Average
    - Below average
    - Poor
    - Not applicable

    Computer devices (desktops, laptops, or tablets)
    - Excellent
    - Above average
    - Average
    - Below average
    - Poor
    - Not applicable

    Interactive whiteboards or display devices (e.g., LCD projector, large monitors)
    - Excellent
    - Above average
    - Average
    - Below average
    - Poor
    - Not applicable

    Support for problems disrupting instruction
    - Excellent
    - Above average
    - Average
    - Below average
    - Poor
    - Not applicable

    Answers to routine questions
    - Excellent
    - Above average

- Average
- Below average
- Poor
- Not applicable

Instructional technology planning
- Excellent
- Above average
- Average
- Below average
- Poor
- Not applicable

Hardware repair
- Excellent
- Above average
- Average
- Below average
- Poor
- Not applicable

51. Rate the average response speed for receiving the following services.

Support for problems disrupting instruction
- Within an hour
- Same day
- Within 24 hours
- Within 1 week
- Longer than 1 week
- I can’t get help

Answers to routine questions
- Excellent
- Above average
- Average
- Below average
- Poor
- Not applicable

Instructional technology planning
- Excellent
- Above average
- Average
- Below average

- Poor
- Not applicable

Hardware repair
- Excellent
- Above average
- Average
- Below average
- Poor
- Not applicable

52. Indicate how strongly you agree or disagree with the following statements.

Technology use in the classroom enhances student learning
- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

I think that learning is more engaging when using technology
- Excellent
- Above average
- Average
- Below average
- Poor
- Not applicable

My school encourages technology use for teaching and learning
- Excellent
- Above average
- Average
- Below average
- Poor
- Not applicable

I want to learn more about effective technology use for teaching and learning
- Excellent
- Above average
- Average
- Below average
- Poor
- Not applicable

I think that computers and technology enhance my daily life

- Excellent
- Above average
- Average
- Below average
- Poor
- Not applicable

53. How often are the following statements true for you?

    My department or grade-level team discusses technology use at meetings
    - All of the time
    - More than half of the time
    - Less than half of the time
    - Rarely

    I discuss technology use during my evaluations
    - All of the time
    - More than half of the time
    - Less than half of the time
    - Rarely

    I discuss technology use during class observations or visits
    - All of the time
    - More than half of the time
    - Less than half of the time
    - Rarely

    I feel recognized for integrating technology into my teaching
    - All of the time
    - More than half of the time
    - Less than half of the time
    - Rarely

54. How many hours have you spent in the past 12 months participating in the following types of educational technology professional development (PD)?

    Formal PD sponsored by the school or district (e.g., in-service days or mentoring)
    - 33 or more hours
    - 17 to 32 hours
    - 9 to 16 hours
    - 1 to 8 hours
    - None

    Formal PD organized by someone other than the school or district (e.g., degree programs, conferences)

- 33 or more hours
- 17 to 32 hours
- 9 to 16 hours
- 1 to 8 hours
- None

Informal PD organized by someone other than the district (e.g., blogs, social media)
- 33 or more hours
- 17 to 32 hours
- 9 to 16 hours
- 1 to 8 hours
- None

55. What is the quality of the following types of educational PD you've completed in the past 12 months?

Formal PD sponsored by the school or district (e.g., in-service days or mentoring)
- Excellent
- Above average
- Average
- Below average
- Poor
- I don't know this

Formal PD organized by someone other than the school or district (e.g., degree programs, conferences)
- Excellent
- Above average
- Average
- Below average
- Poor
- I don't know this

Informal PD organized by someone other than the district (e.g., blogs, social media)
- Excellent
- Above average
- Average
- Below average
- Poor
- I don't know this

56. Which of the following professional development topics are you interested in? (Select up to 7)
- Foundation skills (e.g., file management, device basics)
- Productivity software (e.g., word processing, spreadsheets)

- Multimedia (e.g., video editing, podcasting)
- Online writing and digital communication
- Online collaboration (e.g., working on a project in real time)
- Information management (e.g., using an online document library)
- Classroom management using technology
- Digital collaboration (e.g., working on documents asynchronously)
- Online tools for critical thinking
- Social media
- None of these

57. Do you allow your students to use their personal devices (e.g., laptops, tablets, smartphone) in class for academic reasons?
    - Yes
    - No

58. Are you a special education teacher?
    - Yes
    - No

59. Which grade do you currently teach?

60. Which of the following do you teach?
    - Elementary school
    - Middle school
    - High school

61. How long have you been teaching?
    - 3 or fewer years
    - 4 to 9 years
    - 10 to 19 years
    - 20+ years

62. What subject do you teach?

Appendix B

SURVEY OF TEACHER PERCEPTIONS OF THE LEARNING ENVIRONMENT

Introduction

Thank you for taking the time to respond to this survey. This survey contains 32 questions, including one open-ended response, two demographic questions, and 29 questions that ask you to identify the degree to which you agree with a statement along a 5-point Likert Scale (5=*Strongly Agree, 4=Agree, 3=Neutral, 2=Disagree, and 1=Strongly Disagree*).

There are no correct answers. All responses will be kept confidential, and records will be maintained on a password-protected computer. No identifiable information will be included in any reports of the research published or provided to school administration. A participant number will be assigned to all surveys.

If you have any questions or concerns, please contact Mr. Walker at 661-288-4978 or via email at rwalke48@jhu.edu.

Demographic Questions

1. What subject area do you teach in?
   English
   Mathematics
   Science
   Social Studies

2. How long have you been a full-time, permanent teacher?
   Less than 5 years
   5-10 years
   10-15 years
   15-20 years
   More than 20 years

Defining Student-Centered Learning

3. How would you define student-centered learning?

Metacognitive Learning Opportunities

Please identify the level to which you agree with each of the following statements (Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree)

4. The learning tasks in my classroom support students in developing self-assessment skills.

5. Learning activities in my class help students reflect on what they have learned and how they can grow.

6. It is important that students engage in activities which require them to assess their individual learning and areas of growth.

Personalized Learning Opportunities
Please identify the level to which you agree with each of the following statements (Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree)

7. Helping students feel like they belong in my class is a central concern when I design lessons.

8. I monitor individual process continually to provide feedback on growth and progress.

9. It is important that students take direction and work at the pace I set, when they are working on assignments and projects.

10. Students should be included in decisions about how and what they learn, and how they are assessed.

Opportunities for Creative or Critical Thinking
Please identify the level to which you agree with each of the following statements (Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree)

11. Students should be encouraged to try new approaches to problems or activities, and even fail without repercussions.

12. Learning activities in my classroom are specifically designed to stimulate students higher-order thinking.

13. Learning tasks in my classroom are often designed with a specific answer in mind, which all students are expected to understand by the end of the unit.

Perceptions of Student-Centered Learning
Please identify the level to which you agree with each of the following statements (Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree)

14. Student-centered approaches requires a lot of work and is not realistic for my classroom.

15. Student-centered approaches are incompatible with my subject area.

16. I want to learn more about student-centered instruction.

17. Student-centered approaches are not compatible with our bell schedule.

18. I am ready to create lessons that ask students to solve problems that are meaningful to larger issues or concerns in the world today.

Student-Centered Learning Opportunities (Open Ended Questions)

19. What instructional strategies or tasks would you associate with student-centered learning?

20. Considering he strategies you identified above, to what extent do you utilize any of these strategies or tasks with your current classes?

21. Do you utilize technology to support any of these strategies or tasks? If so, how?

<u>Opportunities for Student Social Interaction or Collaboration</u>
Please identify the level to which you agree with each of the following statements (Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree)

22. A quiet classroom in which students can respond to review questions when prompted is evidence that students are engaged in learning.

23. Students are guided to develop peer assessment skills in my classroom.

24. Lessons in my classroom provide regular opportunities for students to socialize about topics and concepts introduced in my lessons

<u>Authentic Learning Opportunities</u>
Please identify the level to which you agree with each of the following statements (Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree)

25. Learning activities in my classroom are typically designed to relate to contemporary issues or events.

26. It is important to give students increasing responsibility for the learning process.

27. Some lessons are important, even if students don’t find them meaningful.

<u>Perceptions of Student-Centered Learning</u>
Please identify the level to which you agree with each of the following statements (Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree)

28. Student-centered approaches increase the amount of content I can teach.

29. My school leaders are not supportive of student-centered approaches to learning.

30. I am ready to create lessons which ask students to solve problems that are meaningful to them individually.

31. I am not very familiar with student-centered approaches.

32. My students are passive and not always responsible. They are not ready for student-centered approaches in which they take responsibility for their learning.

Closing

Thank you for taking the time to complete this survey. Your answers provide valuable insights into learning and teaching at our school. If you have any questions or concerns about your participation in this survey, please contact Mr. Walker at 661-288-4978 or via email at rwalker@hartdistrict.org.

Appendix C

SURVEY OF STUDENT PERCEPTIONS OF THE LEARNING ENVIRONMENT

Introduction

Thank you for taking the time to respond to this survey. This survey contains 45 questions, including one open-ended response, three demographic questions, and 42 questions that ask you to identify the degree to which you agree with a statement along a 5-point Likert Scale (5=*Strongly Agree, 4=Agree, 3=Neutral, 2=Disagree, and 1=Strongly Disagree*).

There are no correct answers. All responses will be kept confidential, and records will be maintained on a password-protected computer. No identifiable information will be included in any reports of the research published or provided to school administration. A participant number will be assigned to all surveys.

If you have any questions or concerns, please contact Mr. Walker at 661-288-4978 or via email at rwalke48@jhu.edu.

Demographic Information

1. What grade are you currently in?
    - 9th
    - 10th
    - 11th
    - 12th

Learning Environment at Academy of the Canyons

For each of the statements below, please consider your general perception of learning at Academy of the Canyons High School as a whole, not any particular class.

Please identify the level to which you agree with each of the following statements (Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree)

2. Students feel comfortable sharing their ides at this school.

3. Teachers respect my opinions and suggestions.

4. Teachers care about me.

5. Teachers pay attention to what all students are thinking and feeling.

6. Teachers respect my cultural background.

7. Teachers respect me as an individual.

English Class

For the questions on this page, please consider ONLY your current High School English class at Academy of the Canyons.

Please identify the level to which you agree with each of the following statements (Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree)

8. The teacher is the focus for learning in this class.

9. In this class, we spend a lot of time discussing information from the class and collaborating on our work.

10. This class includes opportunities to reflect on my learning and how I can improve as a student.

11. Lectures are the primary method for learning in this class.

12. The lessons in this class are clearly relevant to the world we live in today and are preparing me for success in this world after high school.

13. I am developing strong critical thinking skills in this class.

14. I am free to be creative in how I approach problems and assignments for this class.

15. This class I often boring.

<u>Social Studies Class</u>
For the questions on this page, please consider ONLY your current High School social studies class at Academy of the Canyons.

Please identify the level to which you agree with each of the following statements (Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree)

16. The teacher is the focus for learning in this class.

17. In this class, we spend a lot of time discussing information from the class and collaborating on our work.

18. This class includes opportunities to reflect on my learning and how I can improve as a student.

19. Lectures are the primary method for learning in this class.

20. The lessons in this class are clearly relevant to the world we live in today and are preparing me for success in this world after high school.

21. I am developing strong critical thinking skills in this class.

22. I am free to be creative in how I approach problems and assignments for this class.

23. This class I often boring.

<u>Current Science Class</u>

24. Are you currently enrolled in either high school Biology or Chemistry at Academy of the Canyons?

    Yes

    No, I am taking science classes at the college. (will skip to Mathematics)

    No, I am not enrolled in science this year. (will skip to Mathematics)

<u>Science Class</u>

For the questions on this page, please consider ONLY your current High School science class at Academy of the Canyons.

Please identify the level to which you agree with each of the following statements (Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree)

25. The teacher is the focus for learning in this class.

26. In this class, we spend a lot of time discussing information from the class and collaborating on our work.

27. This class includes opportunities to reflect on my learning and how I can improve as a student.

28. Lectures are the primary method for learning in this class.

29. The lessons in this class are clearly relevant to the world we live in today and are preparing me for success in this world after high school.

30. I am developing strong critical thinking skills in this class.

31. I am free to be creative in how I approach problems and assignments for this class.

32. This class I often boring.

<u>Current Mathematics Class</u>

33. Are you currently enrolled in a high school math class (Algebra I, Algebra II, Honors Algebra II/Trig, or Geometry) at Academy of the Canyons?

    Yes

    No, I am taking math at the college. (skip to finish)

    No, I am not taking math this year. (skip to finish)

<u>Mathematics Class</u>

For the questions on this page, please consider ONLY your current High School math class at Academy of the Canyons.

Please identify the level to which you agree with each of the following statements (Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree)

34. The teacher is the focus for learning in this class.

35. In this class, we spend a lot of time discussing information from the class and collaborating on our work.

36. This class includes opportunities to reflect on my learning and how I can improve as a student.

37. Lectures are the primary method for learning in this class.

38. The lessons in this class are clearly relevant to the world we live in today and are preparing me for success in this world after high school.

39. I am developing strong critical thinking skills in this class.

40. I am free to be creative in how I approach problems and assignments for this class.

41. This class I often boring.

<u>Closing</u>
Thank you for taking the time to complete this survey. Your answers provide valuable insights into learning and teaching at our school. If you have any questions or concerns about your participation in this survey, please contact Mr. Walker at 661-288-4978 or via email at rwalker@hartdistrict.org.

Appendix D

NEEDS ASSESSMENT STUDY OBSERVATION INVENTORY

Teacher: ________________________________

Subject: _________________________________

Observed Teacher Actions	Observed Student Actions	Researcher Reflections

Appendix E

TEACHER INTERVIEW QUESTIONS – NEEDS ASSESSMENT STUDY

Introduction to the Interview (To be read to subjects before beginning interview)

Thank you for taking the time to speak with me today. This interview is part of the data collection process for assessing the role that technology plays in our classes at AOC, especially as it pertains to creating a student-centered learning experience. This is not a formal interview like you would have for a job. The format is semi-structured, so while I will be asking some specific questions, you are not required to address only those questions and are free to answer as you wish. I may ask other, unplanned, questions in order to keep the conversation flowing. I will be recording this conversation in order to establish a reliable transcript for data analysis.

If you get uncomfortable with any question or topic, you are free to shift the conversation to another topic or to end the interview as you see fit. I anticipate this conversation taking about an hour. Do you have any questions before we begin? Do I have your permission to record this conversation?

[*Developer Note: Questions designed specifically as follow up questions are identified by a ½ indent under the primary question they are related to*]

Questions About Technology Integration

What do you see as the role of computer technology, including the use of the Internet, in your classes?

What are some examples of how you use computer technology in your lessons?

Are there other ways that you might use computers other than how they are currently used?

How important do you think it is to bring computer technology into your lessons?

How does using computer technology impact your role as a teacher?

What potential problems or barriers do you see if you were asked to use computer technology, to a greater extent than you already do, in your lessons?

What help or support might you need if you were to integrate computer technology more significantly into your lessons?

Questions About Student-Centered Learning

How would you define your role as a teacher?

How do you engage your students in their learning?

How important do you think it is to create lessons in which students are engaged in solving real-world problems or investigating issues related to our world today?

How would you design such a lesson?

What do you see your role, as a teacher, being in such lessons?

How comfortable would be if you were asked to do this to a greater extent?

What would you need (resources, training, etc.) to make this happen?

Do you think that it is necessary to personalize lessons to individual students? Why?

If yes – how do you go about doing that?

If no – how do you make sure that every student gets the knowledge and support that they need to be successful?

How does this impact your role as a teacher?
If you were asked to create a more personalized learning environment, what would you need? What kind of support? What resources? Etc.

Is there a need for students to reflect on their learning experience in your classes? Why?

If yes – how do you (or could you) do that?

What would you need to be able to create more reflective learning opportunities for your students?

How much time do you think students should spend talking in class? Why?

Do you structure lessons with student conversations in mind?

If someone were to come in and ask you to get your students talking more, how would you do that? What would you need to make it happen?

Final Questions

If you could change one thing about how you teach, what would it be? Why? What would you need (resources, training, etc.) to make this happen?

If I have any other questions, do you mind if I follow up with you at some point?

Appendix F

FREQUENCY OF TEACHER RESPONSES ON PERCEPTIONS OF THE EXISTENCE OF

SCL SUBSCALE (n = 11*)*

Prompt	Strongly Disagree/ Disagree *n* (%)	Neutral *n* (%)	Strongly Agree/ Agree *n* (%)
The learning tasks in my classroom support students in developing self-assessment skills.	0 (0)	1 (9.1)	10 (90.9)
Learning activities in my class allow students to reflect on what they have learned and how they can grow.	0 (0)	1 (9.1)	10 (90.9)
I monitor individual progress continually to provide feedback on growth and progress.	1 (9.1)	1 (9.1)	9 (81.8)
Learning activities in my classroom are specifically designed to stimulate students' higher-order thinking.	0 (0)	0 (0)	11 (100)
Learning tasks in my classroom are often designed without a specific answer or end product that students are expected to produce. (Reverse coded)	5 (45.45)	3 (27.2)	3 (27.2)
Students are guided to develop peer-assessment skills in my classroom.	2 (18.18)	1 (9.1)	8 (72.72)
Lessons in my classroom provide regular opportunities for students to socialize about the topics and concepts introduced in my lessons.	1 (9.1)	0 (0)	10 (90.9)
Learning activities in my classroom are typically designed to relate to contemporary issues or events.	0 (0)	1 (9.1)	10 (90.9)

Appendix G

AVERAGE OF STUDENT RESULTS FROM SSPLE RELATED TO PERCEPTIONS OF THE LEARNING ENVIRONMENT (n = 284)

Prompt	English M (SD)	Math M (SD)	Science M (SD)	Social Studies M (SD)	All Disciplines M (SD)
Directed Learning Subscale					
The teacher is the focus for learning in this class.	3.87 (0.89)	4.42 (0.70)	3.89 (0.85)	3.76 (0.97)	3.87 (0.73)
Lectures are the primary method for learning in this class.	2.95 (1.12)	4.21 (1.08)	3.42 (1.07)	3.47 (1.08)	3.31 (0.85)
Subscale score	3.42 (0.82)	4.31 (0.76)	3.67 (0.78)	3.63 (0.88)	3.59 (0.68)
Reflection Subscale					
This class includes opportunities to reflect on my learning and how I can improve as a student.	4.12 (0.856)	4.00 (0.921)	3.70 (0.893)	3.67 (1.05)	3.90 (0.731)
Collaboration Subscale					
In this class, we spend a lot of time discussing information from the class and collaborating on work.	4.32 (0.698)	4.21 (0.911)	3.95 (0.802)	4.22 (0.864)	4.23 (0.581)
Authentic Learning Subscale					
The lessons in this class are clearly relevant to the world we live in today and are preparing me for success in this world after high school.	4.00 (1.03)	3.52 (1.14)	3.80 (1.03)	4.14 (0.901)	4.00 (0.756)
I am developing strong critical thinking skills in this class.	4.16 (0.869)	3.88 (0.984)	3.64 (0.949)	3.72 (1.03)	3.92 (0.727)
I am free to be creative in how I approach problems and assignments in this class.	3.85 (1.17)	3.54 (1.14)	3.91 (0.095)	4.06 (0.973)	3.93 (0.771)
Subscale Score	4.00 (0.84)	3.64 (0.87)	3.78 (0.72)	3.99 (0.77)	3.95 (0.62)

Appendix H

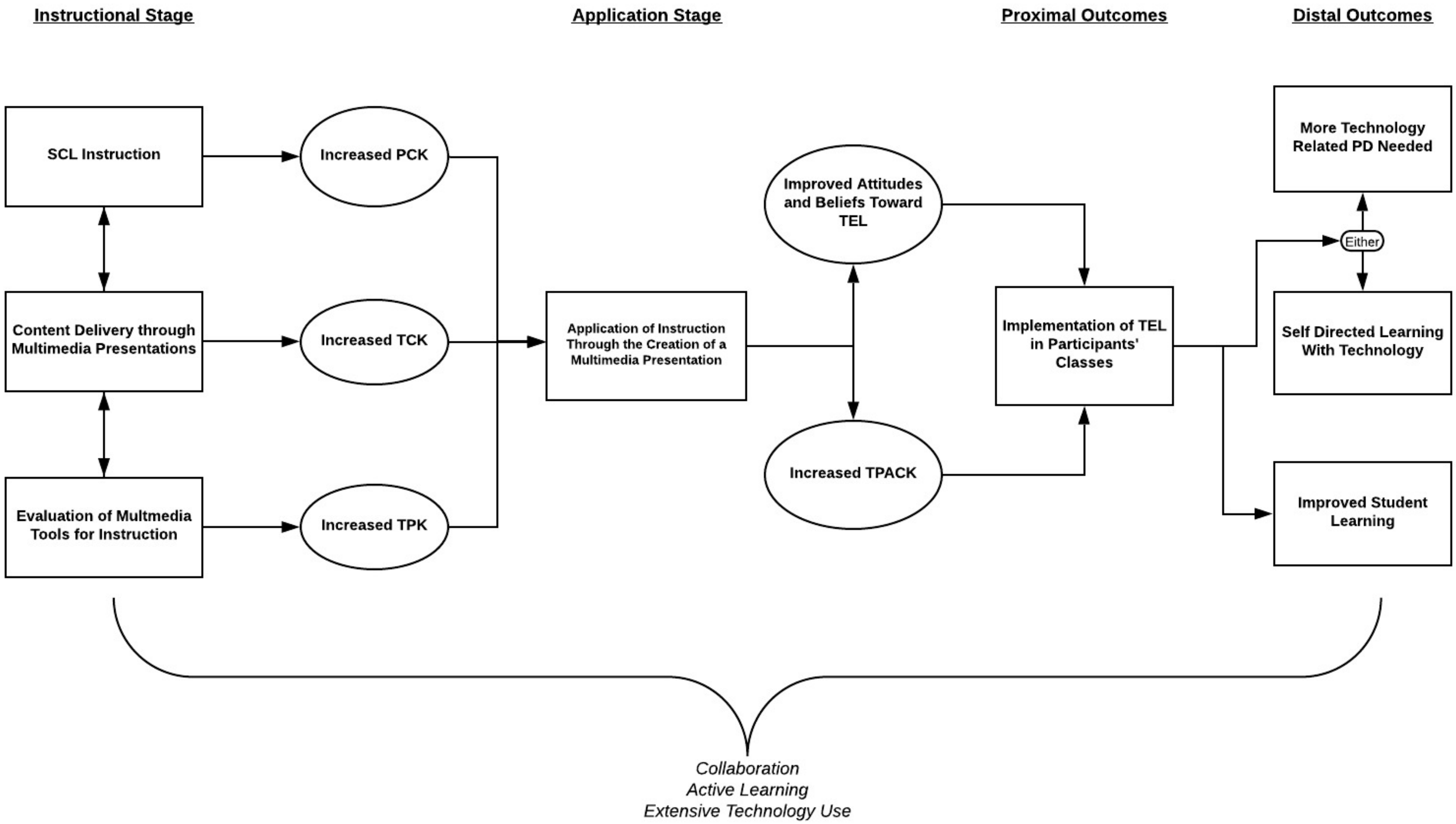
RESULTS FROM CST SURVEY: TEACHER REPORTED FREQUENCY OF COMPUTER USE FOR STUDENT LEARNING

	Teachers				Students			
Prompt	At Least Weekly %	Monthly %	Every Few Months %	Never %	At Least Weekly %	Monthly %	Every Few Months %	Never %
For Any Instructional Purpose	92	0	8	0	82	16	1	0
For Online Writing	9	0	9	82	8	6	19	67
For Collaboration with Classmates	15	62	15	8	73	20	5	2
To Share Documents Online	38	54	0	0	85	11	2	1
To Create and Upload Art, Music, Movies, or Webcasts	8	8	67	17	13	25	34	27
To Develop or Present Multimedia Presentations	42	8	42	8	35	49	14	3
To Collect and Analyze Data	25	50	17	8	50	23	11	17
To Conduct Research	58	25	17	0	80	17	2	1
To Identify and Solve Authentic Problems	33	8	33	25	38	25	16	21
To Create E-Portfolios	25	50	8	17	37	17	17	29
To Conduct Experiments or Perform Measurements	17	8	17	58	37	22	18	23
To Receive Feedback from Other Students	8	25	42	25	16	28	41	15

* Only percentages of total population of participants who used computers for specific purposes (e.g., no discrete numbers) were published in the results from the CST survey. These percentages are reported here.

Appendix I

INTERVENTION CAUSAL MODEL



Appendix J

RESEARCH MATRIX

		Construct	Instruments/Measures (Items)	Timing	Data Analysis
RQ1: Was the PD program implemented with fidelity (Dusenbury et al., 2003), including an emphasis on:					
a)	Program adherence	Program adherence	Field Notes	August – December	A priori coding with the potential for emergent codes
a)	Dosage	Dosage	Exit Surveys (#'s 1-6, 19-22)	October, December	Reporting of frequencies and a priori coding with the potential for emergent codes
b)	Quality of instruction	Quality of instruction	Exit Surveys (#'s 7-11, 23-27)	October, December	Reporting of frequencies, means, and standard deviations, as well as a priori coding with the potential for emergent codes
c)	Participant responses	Participant responses	Exit Surveys (#'s 12-15, 28-31)	October, December	Reporting of frequencies, means, and standard deviations, as well as a priori coding with the potential for emergent codes
Q2: As a result of participating in this program, do participants evidence greater knowledge of:					
a)	SCL practices?	PCK	TPACK Survey (# 4)	September, December	A priori coding with the potential for emergent codes
			Classroom Observations	September, November, February	A priori coding with the potential for emergent codes

		Focus Group Interviews (#'s 1, 5)	September, December	A priori coding with the potential for emergent codes
b) presenting content through different forms of multimedia technology?	TCK	TPACK Survey (# 5)	September, December	A priori coding with the potential for emergent codes
		Classroom Observations	September, November, February	A priori coding with the potential for emergent codes
		Focus Group Interviews (#'s 2, 6)	September, December	A priori coding with the potential for emergent codes
c) use of digital multimedia technology to facilitate SCL practices?	TPK	TPACK Survey (# 6)	September, December	A priori coding with the potential for emergent codes
		Classroom Observations	September, November, February	A priori coding with the potential for emergent codes
		Focus Group Interviews (#'s 2, 5)	September, December	A priori coding with the potential for emergent codes

d) use of SCL practices and multimedia technology to facilitate student learning within their content area?	TPACK	TPACK Survey (#7)	September, December	A priori coding with the potential for emergent codes
		Classroom Observations	September, November, February	A priori coding with the potential for emergent codes
		Focus Group Interviews (#'s 2, 6)	September, December	A priori coding with the potential for emergent codes
Q4: What change in attitudes and beliefs do participants exhibit with regards to:				
a) student-centered learning?	Teacher beliefs and attitudes about SCL	Teaching Teachers For the Future-TPACK Survey (#'s 2, 4, 6, 12, 14, 16)	September, December	Pre and Post Analysis of Descriptive Data; Wilcoxon Signed-Rank Scores
		Focus Group Interviews (#'s 3, 7)	September, December	A priori coding with the potential for emergent codes
		Classroom Observations	September, November, February	A priori coding with the potential for emergent codes

b) digital technology as an instructional tool?	Teacher beliefs and attitudes toward technology	Teaching Teachers For the Future-TPACK Survey (#'s 11-20)	September, December	Pre and Post Analysis of Descriptive Data; Wilcoxon Signed-Rank Scores
		TPACK Survey (#8-12)	September, December	Pre and Post Analysis of Descriptive Data; Wilcoxon Signed-Rank Scores
		Focus Group Interviews (#'s 3, 7)	September, December	A priori coding with the potential for emergent codes
		Classroom Observations	September, November, February	A priori coding with the potential for emergent codes
c) their sense of efficacy toward TEL instructional practices?	Teacher self-efficacy beliefs about TEL	Teaching Teachers For the Future-TPACK Survey (#'s 1-10)	September, December	Pre and Post Analysis of Descriptive Data; Wilcoxon Signed-Rank Scores
		TPACK Survey (#13-17)	September, December	Pre and Post Analysis of Descriptive Data; Wilcoxon Signed-Rank Scores
		Focus Group Interviews (#'s 3, 5, 7)	September, December	A priori coding with the potential for emergent codes
		Classroom Observations		A priori coding with the potential for emergent codes

September,
November, February

Q5: How do participants implement TEL practices within their instructional practice?				
	TEL classroom implementation	Classroom Observations	September, November, February	A priori coding with an eye to emergent codes

Appendix K

PROFESSIONAL DEVELOPMENT EXIT SURVEY

STAGE 1

Thank you for participating in the first part of this professional development program. Over the past few weeks you have reviewed the common elements related to student-centered learning and have evaluated a series of multimedia tools that can be used to present new ideas. Please take a couple of minutes to provide feedback to help improve instruction in this program.

Please indicate which training sessions you participated in by selecting YES or NO next to the session description.

1)	Overview of Student-Centered Learning using Infographics	YES	NO
2)	Examination of Collaboration using Digital Animations	YES	NO
3)	Examination of Authentic tasks using Digital Storytelling	YES	NO
4)	Examination of Critical and Creative Thinking using Self-Guided Presentations	YES	NO
5)	Examination of Personalization of Learning using Digital Animations	YES	NO
6)	Examination of Reflection on Learning using Websites	YES	NO

The facilitator of the trainings I attended …

		Strongly Disagree				Strongly Agree
7)	Was knowledgeable	1	2	3	4	5
8)	Presented information in a clear and consistent manner	1	2	3	4	5
9)	Was engaging	1	2	3	4	5
10)	Made content relevant to me as a teacher	1	2	3	4	5
11)	Was supportive of my needs and questions	1	2	3	4	5

The training I received over the past few weeks…

	Strongly Disagree				Strongly Agree
12) Provided valuable information	1	2	3	4	5
13) Was engaging	1	2	3	4	5
14) Was relevant to my instructional practice	1	2	3	4	5
15) Can be easily integrated into my instructional practice	1	2	3	4	5

16) The element or experience from this training that I feel will be most useful to me as a teacher was…

____

____

____

17) My biggest frustration with this program, so far, has been…

____

____

____

18) Do you have any other comments or questions for the program facilitators at this time?

____

____

____

STAGE 2

Thank you for participating in the second part of this professional development program. Over the past few weeks you have applied your learning about multimedia technologies to build your own multimedia presentation. Please take a couple of minutes to provide feedback to help improve instruction in this program.

Please indicate which support sessions you participated in, while developing your multimedia presentation, by selecting YES or NO next to the session description.

19) Brainstorming	YES	NO
20) Preparing storyboard or draft presentation	YES	NO
21) Storyboard presentation and critique	YES	NO
22) Reflection on design process and presentation creation	YES	NO

The facilitator of the trainings I attended …

	Strongly Disagree				Strongly Agree
23) Was knowledgeable	1	2	3	4	5
24) Presented information in a clear and consistent manner	1	2	3	4	5
25) Was engaging	1	2	3	4	5
26) Made content relevant to me as a teacher	1	2	3	4	5
27) Was supportive of my needs and questions	1	2	3	4	5

The training I received over the past several weeks…

	Strongly Disagree				Strongly Agree
28) Provided valuable information	1	2	3	4	5
29) Was engaging	1	2	3	4	5
30) Was relevant to my instructional practice	1	2	3	4	5

31) Can be easily integrated into my instructional practice	1	2	3	4	5

32) The element or experience from this training that I feel will be most useful to me as a teacher was…

33) My biggest frustration with this program, so far, has been…

34) Do you have any other comments or questions for the program facilitators at this time?

Appendix L

FOCUS GROUP INTERVIEW QUESTIONS

Questions are arranged to note primary and follow-up questions. The construct that each question, or question group, addresses is noted in parentheses. There is redundancy in questions within time points and across time points in order to promote triangulation.

Prestudy Questions

1. Thinking only about your subject (such as English, math, science, or history) what are the best strategies for supporting student learning in your classes? (PCK)
    - How often do you use these strategies in your lessons?
2. What kind of technology do you most often integrate in your lessons? (TCK/TPK)
    - Why are these tools a good fit for your subject area?
    - How are these tools effective at supporting student learning in your content area? (TPACK)
    - How has the use of this technology impacted your teaching?
3. Over the past several years there has been a lot of talk about the need to change instructional practices, especially greater inclusion of technology and using less directed instruction (such as lecturing and rote memorization). To what extent do you agree or disagree with the need to change your instructional strategies or to integrate more digital technology into your instructional practice? (Attitudes and Beliefs toward TEL)
    - How comfortable are you in making these changes? (Self-Efficacy Beliefs)

- What do you see as the biggest challenges to making these changes?

Poststudy Questions

4. Thinking about you experience in this program, including the instruction on student-centered learning, the use of multimedia tools for presentation, and the design process for creating a presentation, what was most valuable to you as a teacher? (Impact of participant experience on program)
    - When and how did this training impact your instructional practice, if at all? How did students respond to these changes? How does that response make you feel? (Impact of non-participants on program)
    - Was there any part of this training that didn't really fit with your professional practice or with the culture of our school? (Impact of professional context on program)
5. How has your thinking about student-centered instruction changed over the course of this program? (PCK)
    - What aspects of student-centered learning do you think you will use in future classes? (PCK/ Attitude & Beliefs)
    - In what ways do you see technology supporting those practices? (TPK)
    - How confident are you that you can make these changes? (Self-Efficacy Beliefs)
6. Can you describe your experience in designing and delivering your own multimedia presentation? In particular, in what ways do you now have a better understanding of the technology that you worked with? (TCK)
    - Based on your experiences in this program, are there are multimedia tools that you feel are best suited for supporting student learning in your subject area? (TPACK)
7. Thinking about your experience designing your own multimedia presentation as well as implementing a student-centered multimedia project in your classroom, has your

opinion or thoughts about technology integration changed at all over this semester? How? (Attitudes and Beliefs toward TEL)

- Do you feel more confident in your ability to integrate technology or student-centered practices into your lessons? How? (Self-Efficacy)

Appendix M

TEACHING TEACHERS FOR THE FUTURE-TPACK SURVEY

(Adapted from Jamieson-Proctor et al., 2013)

Thank you for taking the time to answer these questions related to your perceptions of technology as an instructional tool. This survey is divided into two sections. The first ten questions will ask you to identify your confidence in your knowledge, skills, and abilities with regards to using technology within your instructional practice. Numbers 11-20 will ask you to identify the extent to which you find technology a useful tool for supporting student learning in your classroom.

On a scale of 1-5, with 1 being NOT AT ALL CONFIDENT and 5 being VERY CONFIDENT, how confident are you that you have the knowledge, skills, and abilities to…

demonstrate knowledge of a range of technology to engage students.	1	2	3	4	5
use technology to personalize learning activities for students.	1	2	3	4	5
use technology to teach specific subject areas in creative ways.	1	2	3	4	5
design technology-enhanced activities that enable students to become active participants in their own learning.	1	2	3	4	5
select and use a variety of digital media and formats to communicate information.	1	2	3	4	5
actively construct their own knowledge in collaboration with their peers and others.	1	2	3	4	5
acquire the knowledge, skills, abilities and attitudes to deal with on-going technological change.	1	2	3	4	5
integrate different media to create appropriate products.	1	2	3	4	5
facilitate the integration of curriculum areas to construct multidisciplinary knowledge.	1	2	3	4	5
gather information and communicate with a known audience	1	2	3	4	5

On a scale of 1-5, with 1 being NOT AT ALL CONFIDENT and 5 being VERY CONFIDENT how <u>useful</u> is it for you, as a teacher, or for your students to…

demonstrate knowledge of a range of technology to engage students.	1	2	3	4	5
use technology to personalize learning activities for students.	1	2	3	4	5
use technology to teach specific subject areas in creative ways.	1	2	3	4	5
design technology-enhanced activities that enable students to become active participants in their own learning.	1	2	3	4	5
select and use a variety of digital media and formats to communicate information.	1	2	3	4	5
actively construct their own knowledge in collaboration with their peers and others.	1	2	3	4	5
acquire the knowledge, skills, abilities and attitudes to deal with on-going technological change.	1	2	3	4	5
integrate different media to create appropriate products.	1	2	3	4	5
facilitate the integration of curriculum areas to construct multidisciplinary knowledge.	1	2	3	4	5
gather information and communicate with a known audience.	1	2	3	4	5

Appendix N

TPACK SURVEY

Demographic Questions

1. What is your participant Number?
2. What subject area do you teach in?

   English

   Mathematics

   Science

   Social Studies

3. How long have you been a full-time, permanent teacher?

   Less than 5 years

   5-10 years

   10-15 years

   15-20 years

   More than 20 years

4. Content can be delivered to students in many different ways. Some forms of delivering content may work better in certain subject areas than they do in others. In your opinion, what instructional practices or strategies are particularly well suited to supporting learning within your subject area? Why? (PCK)
5. What digital technologies (i.e., websites, presentation tools, video creation tools, word processers, etc.) are best suited for supporting learning within your subject area? Are there any that are NOT well suited? Why? (TCK)

6. In what ways can technology support the teaching process or help make learning more effective? If possible, please give an example. (TPK)
7. Consider one piece of digital technology (i.e., websites, video/audio recording or editing tools, presentation tools, etc.) that you have integrated into your instruction or would like to integrate. How has, or might, that technology support students in learning the content in your classes (note: you may include tools that supported collaboration or research that facilitated learning content)? (TPACK)

On a scale of 1-5, with 1 being NOT AT ALL and 5 being EXTENSIVE EXPERIENCE, how <u>much experience do you have in using the following digital tools within your instructional practice:</u>

8. Digital Animation	1	2	3	4	5
9. Digital Storytelling	1	2	3	4	5
10. Infographics	1	2	3	4	5
11. Website Design	1	2	3	4	5
12. Self-Guided Digital Presentation Tools (such as Prezi)	1	2	3	4	5

On a scale of 1-5, with 1 being NOT AT ALL CONFIDENT and 5 being VERY CONFIDENT, how <u>confident are you that you can use the following digital tools:</u>

13. Digital Animation	1	2	3	4	5
14. Digital Storytelling	1	2	3	4	5
15. Infographics	1	2	3	4	5
16. Website Design	1	2	3	4	5
17. Self-Guided Digital Presentation Tools (such as Prezi)	1	2	3	4	5

Appendix O

TECHNOLOGY OBSERVATION CHECKLIST

(Adapted from Wang, Hsu, Reeves & Coster, 2014)

Teacher: ________________________________ **Date:** _________________

Environment:

□ Classroom □ Science lab □ Computer lab □ Media Center □ other_______

Hardware used in this class:

Teacher:
□ iPad □ Computer □ ELMO Projector □ Projection Screen □ Other________________

Students:
□ Student Computers (including laptops) _____ □ Student iPad (#) ___ □ ELMO Projector □ Projection Screen □ Other________________

Software/Digital Tools use in this class:

Teacher:
□ Internet □ Slideshow Presentation □ Video Production □ Graphic Creation □ Website Design □ Other________________

Students:
□ Internet □ Slideshow Presentation □ Video Production □ Graphic Creation □ Website Design □ Other________________

DETAILED RUNNING NOTES OF OBSERVATION

Appendix P

PD INSTRUCTIONAL MATRIX

The following chart details the activities that participants will be engaged in during the course of the proposed program.

Instruction Stage	Direct instruction, reflection, and discussion on Mayer's (2008) tenets and principles of effective multimedia design as applied to presentations concerning the core concepts of SCL; addresses Know-What, Know-Why, and Know-How stages of McKenney et al. (2015)				
			August 13-31		
Multimedia Format (for Delivering Content and Evaluation)	Infographics	Digital Animations	Digital Stories	Self-Guided Presentations	Websites
Content Focus	Introduction to Mayer's Principles of Effective Multimedia Design and the critical components of SCL (Mayer, 2009)	Review of collaboration (Daigle, 2000; Dole et al., 2016) as a core component of SCL	Review of the use of student choice and meaningful topics as elements of authentic tasks (Ballard & Butler, 2011; Dole, Bloom, & Kowalske, 2016; McCombs, 2009), a core component of SCL	Review of critical thinking (McCombs, 2001; Ponte, 2006) and creative thinking (Buxeda & Moore, 2001; Daigle, 2000; Dole, Bloom, & Kowalske, 2016) as elements of authentic tasks, a core aspect of SCL	Review of student reflection (Buxeda & Moore, 2001; Grant & Hill, 2006; Ponte, 2006) as a component of SCL
Time Required	45 min (F2F)	45 min (F2F)	45 min (F2F)	45 min (F2F)	45 min (F2F)

Application Stage	Participants will design and execute a presentation, using one of the medium covered in the instructional phase, as a means of presenting specific content as well as modeling use of a particular presentation medium (may be done individually or in a group); addresses Know-How, Know-When, Know-Who, and Know-Where stages of McKenney et al. (2015)						
	Sept 7- Oct 5						
Activity	Participants will engage in a brainstorming session to identify their content focus and medium of presentation (Hardiman, 2012)	Participants will create a storyboard or draft sketch of their proposed presentation (Johnson, 2013; McKenney et al., 2015)	Participants will finalize the storyboard or draft of their proposed presentation (Johnson, 2013; McKenney et al., 2015)	Participants will present their storyboard or draft sketch for review and feedback from other participants as well as select the platform they will use to create their presentation (McKenny et al., 2015; Scott & Mouza, 2007)	Participants will develop their presentation based on the feedback they received and using the platform they selected (McKenny et al., 2015; Scott & Mouza, 2007)	Participants will deliver their presentation to their students	Participants will engage in a collective reflection on the process of designing and creating their presentation (e.g., mid-study focus group interview)
Time	30 min (F2F)	45 min (F2F)	1 Hour (Self-Directed)	45 min (F2F)	1-2 Hour (Self-Directed)	One class session	30 min (F2F

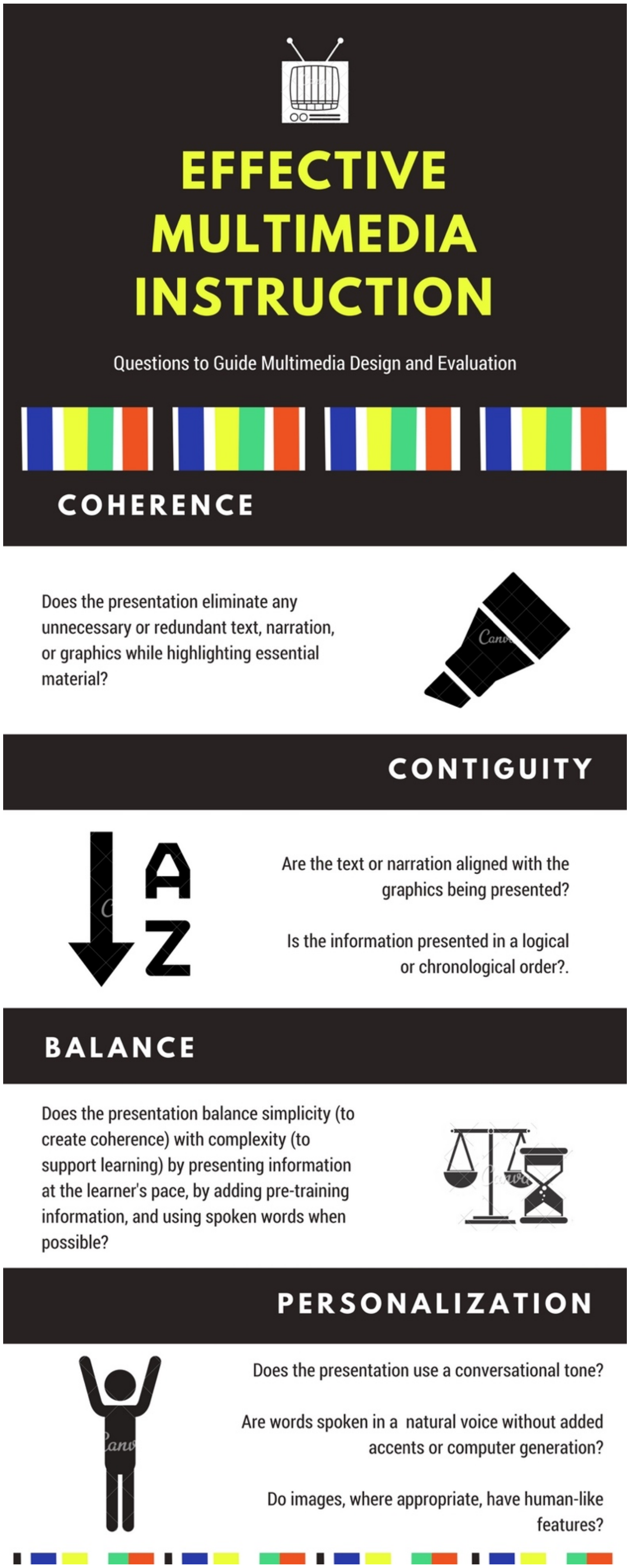
Total Time: Approximately 6 1/2 hours of Face-To-Face interaction, and approximately 2-3 hours of self-directed activities

Appendix Q

SAMPLE MULTIMEDIA PRESENTATIONS

The two infographics, provided below, one entitled "Elements of Student-Centered Learning" and the other "Effective Multimedia Instruction" will be used as initial presentations in the proposed intervention. Similarly, the website located at https://sites.google.com/view/creative-scl will be used for instruction on creative thinking, while the blog located at https://crtical-thinking-scl.blogspot.com/ will be used for instruction on critical thinking. These are some examples of the instructional materials that will be used to guide instruction into SCL practices using multimedia digital technologies.

Elements of Student-Centered Learning
SIX KEYS TO 21ST-CENTURY LEARNING
1.) COLLABORATION
When students work together they are able to share ideas and debate new concepts, creating a deeper understanding of what they are learning.
2.) AUTHENTIC TASKS
Tasks that are ill defined and based on issues and events that are directly relevant to students and their world are more meaningful and require greater cognitive effort and, thus, deeper learning.
3.) PERSONALIZATION
When students have a hand in selecting the topics they will investigate, how a task is designed, or the way in which they present their findings, they are more motivated to learn.
4.) REFLECTION
By pausing to regularly reflect on their learning, students are able to better understand their strengths and areas of growth as learners, and to develop a deeper conceptual understanding of the knowledge they are engaged with.
5.) CRITICAL THINKING
When students are engaged with tasks that require them to make and defend well-reasoned arguments related to content, they develop a stronger understanding of the content as well as the ability to solve problems outside the classroom.
6.) CREATIVITY
By pausing to regularly reflect on their learning, students are able to better understand their strengths and areas of growth as learners, and to develop a deeper conceptual understanding of the knowledge they are engaged with.


EFFECTIVE MULTIMEDIA INSTRUCTION
Questions to Guide Multimedia Design and Evaluation
COHERENCE
Does the presentation eliminate any unnecessary or redundant text, narration, or graphics while highlighting essential material?
CONTIGUITY
A
Z
Are the text or narration aligned with the graphics being presented?
Is the information presented in a logical or chronological order?.
BALANCE
Does the presentation balance simplicity (to create coherence) with complexity (to support learning) by presenting information at the learner's pace, by adding pre-training information, and using spoken words when possible?
PERSONALIZATION
Does the presentation use a conversational tone?
Are words spoken in a natural voice without added accents or computer generation?
Do images, where appropriate, have human-like features?

Appendix R

CODEBOOK

Code	Sub Code	Definition	Example
PCK		Pedagogical Content Knowledge: Knowledge of the practices and strategies that best support learning within a teachers' specific content area.	Okay, do I have to-- and I don't want to be extreme here, but one way to look at it is I have to re-envision my curriculum. I have to re-envision my practice and my pacing. If we're going to follow my prospectus, I have to re-envision how I can do that to get these skill sets over to them. Let them practice. Let them learn but let me be a guide.
	PCK-Weak	A limited understanding of the practices, strategies, or principles that promote learning within a teacher's specific content area; practices may be routine and rely on basic memorization, simple question and answer, or lecture, without clear intent to have students apply learning or represent content in multiple ways; limited or no real effort to adjust practices in relation to students' prior knowledge.	[When asked the best way to teach content within their specific content area] Grammar? Teaching the structures of argumentation, like I tried to do this year.
	PCK-Strong	Clear understanding of practices and strategies that are specific to promoting learning within a teacher's content area including ability to interpret subject matter, find multiple ways to represent content, or adapt practices or materials to	That's kind of a trend and so on the other hand, there's still those old-world skills. Yeah, I can make my grammar stuff a little more polished. But subject-verb agreement, and making those match is subject-verb agreement. And I could do the technology behind it, and I can put the time in to make it glossy, but still there's that piece, whether it's direction, or the actual writing of, we

		adjust for students' prior knowledge.	need to produce argumentation papers or what have you. Those skills too, it's the balance. And I want to work that out.
TCK		Technological Content Knowledge:Understanding of the ways in which technology can influence or support the delivery of content within a specific subject area including knowledge of specific technologies that are best suited for addressing subject matter learning within that content area.	I was thinking something along the lines for our ninth-grade group project that we do for showcase in the spring, and I was thinking of creating a gallery for those kind of projects. So instead of having them up in our rooms, just one of the rooms since it is we're trying to do all these interdisciplinary activities, have one of them build a website, call it a gallery, and then they can upload it there so you have a place for all of them to enjoy and then to learn from each other because that's what I found.
	TCK-Weak	A limited understanding of the technologies that can support the presentation and dissemination of content within a teacher's specific subject area including a narrow focus on one or more tools that do not or cannot present content in multiple or dynamic manners.	Presentation tools especially. I use word processing a great deal, obviously, but other suites...?
	TCK-Strong	A deep understanding of the manner in which a teacher's specific content can be changed through the application of technology including an understanding of the specific technologies that are best suited for addressing the specific subject matter.	So two groups used the poster in conjunction with other things. One group made an Instagram and a website to sell their fake product because it was about advertising, and so they decided to use that and then nothing else. And it was maybe one of the best ones. The kids actually shied away from just doing a traditional presentation using Prezi, or, I think, one group actually did just a slide presentation, and by time they saw everyone else, they immediately regretted it because they realized they could have done more.

TPK		Knowledge of the pedagogical affordances and constraints of technology within a specific content area.	Less is more. Especially with web design, less is more. I'm all about that engagement component. I'm all about that creating the need to know just showing them a phenomenon and be like, "Well, I've got to figure that out in the next two weeks." Yeah, I wasn't abiding by that when I'm like, "I want a website to be the end all, frequently asked questions. You can go there and get it." Why? Use it as an engagement process. Use it as something to generate inquiry.
	TPK-Weak	A limited understanding of the technologies that can support learning within a teacher's specific subject area or a lack of understanding of how specific tools support or limit learning within the content area.	[When asked how technology can support the teaching process] Use of the occasional video. Student presentation work.
	TPK-Strong	A deep understanding of the manner in which learning within a specific content area is better supported through the application of technology including the ways in which specific tools can support or limit learning within that content area.	Technology-enhanced instructional practices can provide multi-modal (VAKT) delivery of instruction, engage the learner by competing with the abbreviated, succinct nature of 21st century media bombardment, and perhaps most importantly, marry content delivery with skill-set instruction to drive innovation and competition for the global economy our students will be entering.
TPACK		Knowledge, specific to a given subject matter, of the potential for representing concepts with technology; the pedagogical techniques for using technology in a constructive way; of what makes concepts easier or more difficult to learn	Integrating websites have helped students in multiple ways. 1) students are better able to evaluate website content and design. 2) Students can use websites to house and communicate information in an engaging and practical manner. 3) Students can refer back to these work products to reflect on their work. 4) STudents can share their work with peers for support,

		with technology; of students' prior knowledge; and of how technology can be used to build upon that prior knowledge to build new knowledge.	criticism, and additional examples of how the medium can be used effectively.
	TPACK-Weak	Limited understanding of how to represent content using technology within a teacher's specific subject matter; how technology facilitates learning within that content area; how to use technology to tap into student's prior knowledge and build upon that knowledge to foster learning within the specific content area; as well an limited understanding of practices and techniques specific to that subject area that use technology to constructively teach content.	I have found documentary videos to be very helpful in assisting students in understanding some of the deeper meaning in the novel To Kill a Mockingbird.
	TPACK-Strong	Deep and specific knowledge of how to represent content using technology within a teacher's specific subject matter; how technology facilitates learning and can make difficult concepts within that content area easier to learn; how to use technology to tap into student's prior knowledge and build upon that knowledge to foster learning within the specific content area; as well an understanding of practices and techniques	I'm looking at that going like, "Oh, that's really clever for a PB." And then, all of a sudden, nitrogen cycle jumps in my mind. So seeing it done well, I really do think is awesome. So if there are further opportunities for us to showcase-- if we kind of see what the 10th grade did, maybe if we could carve out 15 minutes at one of our PBs in January, that would be really cool because then I will get motivated and try something like that. Where I would have, "Animations don't--" for science, it's more like the coggles, or like the [lucid?] charts, thought mapping of complex that, "Well, no. You could tell a story. You can do a narrative in science."

		specific to that subject area that use technology to constructively teach content.	
Attitudes/Beliefs		Beliefs are ideas or principles that a participant holds to be true while an attitude is an expression of that belief (thus this code identifies the attitudes that are reflective of the beliefs that participants hold).	What was good for me was, I think as teachers we want to be the expert and I'm not technology savvy in terms of social media and that kind of thing either.
	TEL-Affordances	Expressions what participants perceive as facilitating practices consistent with technology-enhanced instruction within a participant's class(es).	Just focusing on the real-world applications, and that's really helpful knowing that colleges and businesses have thought about that-- that that might be in their future, another reason that they need to work on presentations and also video skills.
	TEL-Barriers	Evidence of barriers to the integration of TEL strategies and practices.	But on the other hand, seeing these different options here that were presented to us, the initial response might be, "I don't see room for that in my class. I'm working on reading this fiction so I don't see room for this." I think if we go back to kind of the basis of our curriculum design, instructional design, maybe there is room for that, and it takes either some more examples for just one specific use or more creativity, thinking outside the box, and also potentially, I might find it to be not immediately relevant.
	TEL Self-Efficacy	The confidence that a participant exhibits with regard to integrating TEL practices.	So I think for me, the challenge is just letting go and letting kids pick up and do more things. And letting them experiment with the different things instead of me having to learn all of it.
	TEL Self-Efficacy - Weak	A participant's expressed belief that they are not confident or capable of	Common Core has come in and they're trying to compensate for the lack of conceptual understanding, and so that

		integrating practices consistent with technology-enhanced learning within their class(es).	they're almost throwing out skills. So you still have to have skills in order to do those things and to be able to understand the greater concept.
	TEL Self-Efficacy - Strong	Expressed confidence in a participant's ability to integrate practices consistent with technology-enhanced practices within their class(es).	[When asked about changing perceptions about student-centered learning] I don't know if my thinking about it has changed, but my experience went through the roof.
	Tech Use Self-Efficacy	The confidence that a participant exhibits with regard to their ability to use digital technology tools	I made a document. I just went online and tested out a bunch of different apps and websites and found about 25 that were really good and made a document and put it on Google Classroom and let them play with the different platforms as well.
	Tech Use Self-Efficacy - Weak	A participant's expressed belief that they are not comfortable with or capable of using technology effectively.	It's just so weird, it's just like, "I can't get into my document," and then I'm, "Why not?" "Well, you haven't returned it." I'm like, "Oh, did I need to do that? Okay."
	Tech Use Self-Efficacy - Strong	A participant's expressed belief that they can effectively use technology.	So on this -with technology [participant] had brought up. It would be really cool to use augmented reality for the next showcase... Augmented reality means placing objects [laughter] that aren't actually here in this environment. And I found an app in this place that will let you put in work into the world through the app.
Implementation		Evidence that a participant is or had implemented elements of TEL within their classroom instruction.	From classroom observation: Lesson was predominantly technology-enhanced with students engaged in creating a period-long lesson on a dictator to give to their class. This collaborative project required students to consider how to engage their peers in learning about a dictator and the impact that that person had on the government

			structure and people of their nation. At least one element of that engagement had to be an interactive, technology-based activity, requiring students to explore different technologies that they could use to create interactive activities.
Process Evaluation		Evidence from collected data as to the effectiveness of the program as it was implemented	Well, definitely. For the sophomore class, we designed our whole showcase around the idea of implementing different forms of technology. [Participant] did animation. I did infographics. They built a website and then they recorded recordings of their speeches. So now they have four different ways to present information. So I think opening our eyes to all the varieties of that definitely impacted our kids and our instruction.
	Adherence	Extent to which program activities were consistent with the design of the program	[From Research Journal] He asked me to put together a schedule for the sessions, but asked that I consider condensing them so that two presentations could be covered in an hour session
	Dosage	amount of program content received by participants (i.e., number of sessions and duration or intensity)	[From Research Journal] Today's session started late, as everyone arrived 10-15 minutes late. Three people were not present: 1543 (who is out today), 1729 (who had previously indicated that he would not be there) and 1131 (who did not notify me that she would not be present).
	Qual_Instruction	How participants perceived the quality and effectiveness of the instructor or instruction they received	[From Research Journal] Later, Michele E and Sharon (separately) stopped me to say that the session was good and that they got a lot out of the presentations.
	Part_Responses	How participants perceived their engagement and involvement in the	[From Research Journal] She seemed frustrated with the process, but interested in continuing to work with

		activities and content of the study.	the technology to see how she could use it more effectively in class.

Resume

Robert Walker
Academy of the Canyons MCHS
Santa Clarita, CA
661-362-3056

27664 Muir Grove Way
Castaic, CA
661-803-1966

Education

January 2020	**Doctorate of Education,** Instructional Design for Digital Learning Environments. Johns Hopkins University.
January 2014	**Masters of Education**, Educational Leadership. University of LaVerne.
January 2014	**Preliminary Administrative Services Credential**. University of LaVerne.
December 2004	**Masters of Arts**, Educational Technology. California State University, Northridge.
December 2004	**Single Subject Teaching Credential**, Social Studies. California State University, Northridge.
June 2001	**Master of Arts**, History. Stanford University.
September 2000	**Bachelor of Arts**, History. University of California, Davis.

Teaching Experience

2004-Present	**Academy of the Canyons Middle College HS** Santa Clarita, CA Social Studies Teacher.
2003-2004	**Bishop Alemany High School** Mission Hills, CA Social Studies Teacher.